# ಕರ್ನಾಟಕ ರಾಜ್ಯಪತ್ರ

**ಅಧಿಕೃತವಾಗಿ ಪ್ರಕಟಿಸಲಾದುದು**


| ಸಂಪುಟ –೧೫೮<br>**Volume - 158** | ಬೆಂಗಳೂರು, ಸೋಮವಾರ, ೦೯, ಅಕ್ಟೋಬರ್, ೨೦೨೩(ಆಶ್ವಯುಜ , ೧೭, ಶಕವರ್ಷ, ೧೯೪೫)<br>**BENGALURU, MONDAY, 09, OCTOBER, 2023(AASHWAYUJA , 17, SHAKAVARSHA, 1945)** | ಸಂಚಿಕೆ ೧೯೫<br>**Issue 195** |
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**ಭಾಗ ೪**

**ಕೇಂದ್ರದ ವಿಧೇಯಕಗಳು ಮತ್ತು ಅವುಗಳ ಮೇಲೆ ಪರಿಶೀಲನಾ ಸಮಿತಿಯ ವರದಿಗಳು, ಕೇಂದ್ರದ ಅಧಿನಿಯಮಗಳು ಮತ್ತು ಅಧ್ಯಾದೇಶಗಳು, ಕೇಂದ್ರ ಸರ್ಕಾರದವರು ಹೊರಡಿಸಿದ ಸಾಮಾನ್ಯ ಶಾಸನಬದ್ಧ ನಿಯಮಗಳು ಮತ್ತು ಶಾಸನಬದ್ಧ ಆದೇಶಗಳು ಮತ್ತು ರಾಷ್ಟ್ರಪತಿಯವರಿಂದ ರಚಿತವಾಗಿ ರಾಜ್ಯ ಸರ್ಕಾರದವರಿಂದ ಪುನಃ ಪ್ರಕಟವಾದ ಆದೇಶಗಳು**

## ಸಂಸದೀಯ ವ್ಯವಹಾರಗಳು ಮತ್ತು ಶಾಸನ ರಚನೆ ಇಲಾಖೆ

## ಅಧಿಸೂಚನೆ

ಸಂಖ್ಯೆ: ಸಂವ್ಯಶಾಇ 36 ಕೇನಿಪ್ರ 2023 ಬೆಂಗಳೂರು, ದಿನಾಂಕ: 06.10.2023.

ದಿನಾಂಕ: 16.08.2023 ರಂದು ಭಾರತ ಸರ್ಕಾರದ ಗೆಜೆಟ್‌ನ ವಿಶೇಷ ಸಂಚಿಕೆಯ Part-II-Section-3 Sub Section (i)ರಲ್ಲಿ ಪ್ರಕಟವಾದ the Inland Vessels (Design and Construction) Rules 2023ರ Notification-GSR 605(E) ಅನ್ನು ಸಾರ್ವಜನಿಕರ ಮಾಹಿತಿಗಾಗಿ ಕರ್ನಾಟಕ ರಾಜ್ಯಪತ್ರದಲ್ಲಿ ಮರು ಪ್ರಕಟಿಸಲಾಗಿದೆ,-

**MINISTRY OF PORTS, SHIPPING AND WATERWAYS**

**NOTIFICATION**

New Delhi, the 16th August, 2023

**G.S.R. 605(E).—**The draft of the Inland Vessels (Design and Construction) Rules 2023, which the Central Government proposes to make, in the exercise of the powers conferred by sub-section (1) of section 106 of the Inland Vessels Act of 2021 (24 of 2021), is hereby published for the information of all persons likely to be affected thereby; and notice is hereby given that the said draft shall be taken into consideration after thirty days from the date on which the copies of this notification as published in the Official Gazette are made available to the public;

Objections or suggestions, if any, to these draft rules may be sent to the Director (IWT), Ministry of Ports, Shipping & Waterways, Room No. 251, Transport Bhawan, 1-Parliament Street, New Delhi-110001, or by email at avneet.kaur@nic.in and uttam.mishra27@gov.in within the period specified above;

The objections or suggestions which may be received from any person concerning the said draft rules, within the period so specified will be considered by the Central Government.

**CHAPTER I**

**PRELIMINARY**

1. **Short title and commencement. –** (1) These rules may be called the Inland Vessels (Design and Construction) Rules 2023.

(2) They shall come into force on the date of their publication in the Official Gazette.

2. **Scope and application.-** Unless otherwise specified in these rules, these rules shall be applicable to inland vessels, which are obligated to be registered under the Inland Vessels Act, 2021or those vessels that are operating in the inland waters of India.

3. **Definitions. -** (1) In these rules, unless the context otherwise requires,

(a) "act "means the Inland Vessels Act, 2021(24 of 2021);

(b) "cargo vessel" means any mechanically propelled inland vessel which is not a passenger vessel;

(c) "decked vessel" means vessel with a continuous watertight weather deck that extends from stem to stern;

(d) "existing vessel" or "existing inland vessel" means any inland vessel which is not any new inland vessel that falls within the ambit of the definition provided under clause (l);

(e) "freeboard" means the distance measured vertically downwards from the lowest point of the upper edge of the weather deck to the waterline in still water or, for an open boat, the distance measured vertically downwards from thelowest point of the gunwale to the waterline;

(f) "freeboard deck" is the uppermost complete deck exposed to weather and waves, which has permanent means of closing all openings in the weather part thereof, and below which all openings in the sides of the vessel are fitted withpermanent means of watertight closing:

***Explanation***: In an inland vessel having a discontinuous freeboard deck, the lowest line of the exposed deck and the continuation of that line parallel to the upper part of the deck is taken as the freeboard deck.

(g) "high-speed vessels" are vessels capable of reaching speeds over 21 Nautical miles per hour in relation to water;

(h) "load water line" means the load line defined under section 3 (u) of the Act;

(i) 'length' or '$L$'is the maximum length of the hull in metres;

(j) 'length' of waterline' or '$L_{\mathrm{Wl}}$'is the length of the hull in metres, measured at the maximum draught;

(k) "major conversion or modification" means any of the following-

(i) change in Gross Tonnage of the vessel by more than ten per centum;

(ii) change of vessel type;

(iii) change of propulsion system or main engines or type of fuel.

(l) "new inland vessel" means any inland vessel whose keel is laid or which is at a similar stage of construction on or after the date of coming into force of the rules;

(m) "open vessel/boat" means a vessel which within its length is: -

(i) not fitted with a watertight weather deck; or

(ii) is fitted with a watertight weather deck over part of its length; or

(iii) is fitted with a watertight weather deck over the whole of its length but the freeboard to the deck does not meet the minimum requirement for freeboard;

(n) 'residual freeboard' is the vertical clearance available, in the event of the vessel heeling over, between the water level and the upper surface of the deck at the lowest point of the immersed side or, if there is no deck, the lowest pointof the upper surface of the fixed vessel's side;

(o) "the standards for design, construction of Inland vessels will be the standards as prescribed under the Rules and Regulations for the Design and Construction of Steel Inland Vessels given at Annex-1 of this Rule. "Sister vessel" is a vessel built from the same plans;

(p) "Gross Tonnage of a vessel" is the Gross tonnage calculated as per the International Tonnage Convention,1969;

(q) "Classification societies" are all those organizations which are. Member of International Association of Classification Societies.

(2) Words and expressions used and not defined in these rules but defined in the Act, shall have the meanings respectivelyassigned to them in the Act.

## CHAPTER II

## CATEGORISATION AND COMPLIANCE

**4. Categorisation of inland vessels. -** For the purpose of these rules, Inland vessels shall be classified as per the following categories: -

(1) Category 'A' vessels which are decked vessels of any of the following types and are operating in Zone 1-

(a) vessels, other than houseboats, that are more than 24 metres in length and houseboats that are more than 30 metres in length;

(b) vessels that carry more than 50 passengers on board;

(c) all vessels equipped for towing other vessels, having a bollard pull capacity exceeding 10 tonnes;

(d) vessels designed and constructed to carry petroleum goods, chemicals or liquefied gases bulk as cargo;

(e)vessels carrying dangerous goods; and

(f) vessels of 300 GT and above.

(2) Category 'A' vessels shall be designed, constructed under the Rules and Regulations for the Design and Construction of Steel Inland Vessels given at Annex-1 of this Rule

(3) Category 'B': Vessels not covered under Category 'A' or Category 'C'.

(4) Category 'B' vessels shall be designed and constructed under the survey of classification society, which is a member of the International Association of Classification Societies and or designed, constructed and maintained under the surveyof the designated authority.

(5) Category 'C': Vessels of length less than 10 metres.

(6) Category 'C' vessels shall be designed, constructed and maintained according to the standards prescribed by the designated authority and maintained under the survey of the designated authority.

(7) Open Vessels operating in Zones 1 and 2, provided that due regard is paid by the master towards any operational restrictions imposed by the local authorities.

**5. Threshold of compliance. –** (1) All existing inland vessels shall comply with the requirements existing prior to coming into force of Inland Vessels Design and Construction Rules 2022;

Provided that the existing inland vessels that undergo major conversion or modification shall comply with the requirements specified in these rules, as far as it is considered reasonable and practicable by the Designated authority,and provided that in the case of change of propulsion system or main engines or type of fuel etc, the new rules shall apply to that equipment and systems only.

(2) Notwithstanding anything contained in sub rule (1), existing inland vessels have to comply with the requirements of stability information and calculation of freeboard mentioned in rules 13 and 15 within two years of coming into force of these rules.

(3) Subject to sub-rule (1), the owner or operator and master of the new vessel, shall ensure that the vessel is constructed, maintained and operated under the requirements of these rules and the vessel is suitable for its intended

service.

(4) No new inland vessel shall be issued with the certificate of survey under the Act, unless such vessel complies with the standards of design and construction requirements.

**6. Materials. -** (1) For Category 'A' and Category 'B' vessels, all materials used for construction shall conform to the requirements and testing standards as prescribed under **the Rules and Regulations for the Design and Construction of Steel Inland Vessels given at Annex-1 of this Rule**

(2) Materials used for the construction of Category 'C' vessels shall conform to the standards considered appropriate bythe designated authority.

**7. Equipment standards and guidance.-** Equipment and types of machinery are required to be carried on board, shall be under Bureau of Indian Standards or International Standards Organization norms.

## CHAPTER III

## SHIPBUILDING, FITTING OUT AND EQUIPMENT

**8. General applicability.-** (1) The requirements in this Chapter include minimum requirements related to Structure, Strength, Freeboard, Subdivision and Stability, Machinery, Bilge Systems, and Electrical Installations.

(2) notwithstanding anything contained in sub-rule (1) above, additional requirements which are applicable to specific types of vessels are included in Part B of these Rules.

(3) This Chapter specifies minimum requirements, which the vessels shall satisfy, and for Category 'A' vessels, they are not an alternative to full compliance of the requirements **as prescribed under** the Rules and Regulations for the Design and Construction of Steel Inland Vessels given at Annex-1 of this Rule.

**9. Design, strength and structural arrangements.–** (1) The structural strength of mechanically propelled inland vessel shall be suitable for the intended service and area of operation and Category 'A' vessels shall comply with the structural requirements of prescribed under **the Rules and Regulations for the Design and Construction of Steel Inland Vessels given at Annex-1 of this Rule**

(2) The structural strength and scantlings of Category 'C' vessels of fibre reinforced plastic and wood material shall be under the requirements of a Class Society which is a member of International Association of Classification Societies or International Standards such as International Standards Organisation acceptable to the designated authority.

(3) The general structure, scantlings and construction of the main structural elements of the hull shall be constructed in conformity with the following criteria-

(a) the nature and characteristics of the materials used, their application and method of assembly;

(b) the type of vessel, its dimensions, its internal arrangements, and the permitted maximum operational draught;

(c) the conditions under which it is operated and any particular distribution of weight on board and the category of navigation;

(4) The maximum permitted draught corresponding to the strength of the vessel, shall remain compatible with thefreeboard assigned to the vessel.

**10. Watertight sub-division and general arrangement.–** (1) Subdivision bulkheads terminating at the freeboard deck or, where there is no deck, up to the gunwale, shall be installed at the following instance:

(a) a collision bulkhead shall be installed at a distance of between 0.04 L and 0.1 L m measured from the forward perpendicular in the plane of maximum draught and, if the bulkhead is fitted aft of the limits prescribed above, it shallbe proved by calculation that in case of flooding of the space forward of the collision bulkhead, the vessel will continue to be buoyant with a residual freeboard of at least 100 millimeters

(b) an aft-peak bulkhead shall be installed at a distance of between 1.4 m and 0.04 L + 2 m measured from the aft point of the intersection of the hull with the maximum draught line and, if the bulkhead is fitted forward of the limitsprescribed above, it shall be proved by calculation that in case of flooding of the space aft of the aft-peak bulkhead, the vessel will continue to be buoyant with a residual freeboard of at least 100 millimeters.

(2) No accommodation spaces or installations needed for vessel safety or operation, except anchoring and steering equipment, shall be located ahead of the plane of the collision bulkhead or aft of the aft-peak bulkhead.

(3) Accommodation spaces, engine rooms, boiler rooms and the workspaces forming part of these shall be separated from cargo holds by watertight transverse bulkheads that extend up to the freeboard deck.

(4) Accommodation spaces shall be separated from engine rooms; boiler rooms and holds and shall be directly

accessible from the deck.

(5) If such arrangement is not provided, an emergency exit that leads directly to the open deck shall be provided in addition to the normal means of access.

(6) The bulkheads mentioned in sub-rule (1) and for the separation of areas specified in sub-rule (3) shall not contain any openings subject to-

(a) the number of pipes piercing the collision bulkhead shall be as small as possible and shall be fitted with suitable valves operable from above the freeboard deck and the valve chest shall be secured at the bulkhead inside the forepeak:

Provided that the designated authority may permit the fitting of suitable valves on the rear of the collision bulkhead if such valves are readily accessible and the space in which they are located is not cargo space;

(b) doors in the aft-peak bulkhead and penetrations, in particular for shafts, ventilation trunks and pipe work, shall be permitted where they are so designed that the effectiveness of those bulkheads and the separation of areas is not impaired and doors in the aft-peak bulkhead shall be permitted only if it can be determined by remote monitoring in the wheelhouse whether they are open or closed and shall bear the following readily legible instruction on both sides 'Door to be closed immediately after use'.

(7) Each watertight subdivision bulkhead, whether transverse or longitudinal, shall be constructed in such a manner thatit shall be capable of supporting, with a proper margin of resistance, the pressure due to a head of water up to the freeboarddeck.

(8) Steps and recesses in subdivision bulkheads shall be watertight and as strong as the bulkhead at the place where theyare located.

(9) Where frames or beams pass through a watertight deck or bulkhead, such deck or bulkhead shall be made structurallywatertight.

(10) Watertight decks, trunks, tunnels, duct keels and ventilation trunks shall be of a type equivalent to the watertightbulkheads located at the same level and the method of construction used to ensure that such elements are watertight, and the arrangements adopted to allow closing of the openings, shall be to the satisfaction of the designated authority.

(11) Watertight ventilation ducts and trunks shall extend at least to the level of the freeboard deck.

(12) The flooding test of main compartments is not compulsory and when a flooding test is not carried out, a hose testshall be done.

(13) The tests provided in sub-rule (12), shall be carried out at an advanced stage of fitting out of the vessel and,a detailed inspection of the watertight bulkhead shall, in any case, be carried out.

(14) The forepeak, double bottom including duct keels and double hulls, where fitted, shall be tested to a pressure corresponding to the requirements provided under sub-rule (6) above.

(15) Tanks intended to hold liquids and form part of the watertight subdivision of the vessel, shall be tested for tightnessand structural strength with water to a head corresponding to its design pressure and the water head shall in no case be less than the top of the air pipes or to a level of 1 m above the top of the tank, whichever is the greater.

**11. Stability. -** (1) The stability particulars of inland vessels shall be adequate to ensure the safe operation of vessels by minimising the risk to the vessel, to the personnel on board and the environment, due regard being given to the vessel's intended serviceand area of operation.

(2) The requirements for stability as contained in this Chapter apply to all vessels, and shall be subject to those requirements as provided in Chapter IV of these Rules.

(3) When voyage commences, care should be taken to ensure that cargo and sizeable pieces of equipment have been properly stowed and lashed to minimize the possibility of both longitudinal and lateral shifting, under the effect of acceleration caused by rolling and pitching.

(4) The number of partially filled or slack tanks should be kept to a minimum to avoid adverse effect on stability.

**12. General intact stability criteria for non-passenger vessels. -** (1) For non-passenger vessels, proof shall be furnished that the following stability requirements have been complied with:-

a) in the positive area of the righting lever curve up to the first non-weathertight opening there shall be a rightinglever (GZ) of not less than 0.10 m;

b) the area of the righting lever curve up to immersion of the first non-weathertight opening and in any event up toan angle of heel of 27 degrees shall not be less than 0.024 m.rad;

c) the meta centric height (GM) shall not be less than 0.15 m.

(2) the conditions provided under this rule shall be met, bearing in mind the influence of all free surfaces in tanks

for all stages of loading and unloading.

(3) for Category 'C' vessels of less than six metres in length, alternatively, the requirements in International Standards Organisation 12217-3 may be applied instead of the criteria mentioned in sub-rule (1).

**13. Stability information. -** (1) Stability data and associated plans are to be drawn up in the working language of the vessels and any other languageas may be required by the designated authority of the State Government in which the vessel is intended to be registered.

(2) All translations of the stability booklet should be approved by the designated authority; and for Category 'A' vessels, the English version of the booklet shall be approved by a Classification society, which is a member of International Association of Classification Societies and versions in any other language shall be approved by designated authority.

(3) The approved stability booklet shall contain sufficient information to enable the master to operate the vessel in compliance with the applicable stability requirements of these rules.

(4) In case of Category 'A' vessels with unusual ornon-uniform weight or cargo distribution; and for all vessels of L ≥ 60m vessels.

(5) The stability booklet shall also include loading guidance information, and information on longitudinal strength.

(6) The information provided in sub-rules (3) to (5) shall be made available to the master to assist in loading the vessel withinits structural design limits and such information shall comprise of:

(a) the longitudinal strength analysis of the most onerous loading conditions anticipated;

(b) maximum permissible still water bending moments, in both hogging and sagging conditions; and

(c) such other details as may be required by the respective designated authority of the State Government in which the vessel is intended to be registered.

(7) The format of stability booklet and the information shall vary depending on the vessel type and operational profile andin general, the following information should be included, as a minimum:

(a) principal particulars of the vessel;

(b) instructions on the use of the booklet;

(c) general arrangement plans showing watertight compartments, closures, vents, down-flooding angles, permanent ballast, allowable deck loadings and free board diagrams;

(d) hydrostatic curves or tables and cross curves of stability calculated on a free-trimming basis, for the ranges ofdisplacement and trim anticipated in normal operating conditions;

(e) capacity plan or tables showing capacities and centres of gravity for each cargo stowage space;

(f) tank sounding tables showing capacities, centres of gravity, and free surface data for each tank;

(g) information on loading restrictions, such as maximum KG or minimum GM curve or table that can be used to determine compliance with the applicable stability criteria, taking into account damage stability, where applicable and such information should be supplemented by the loading guidance information provided in sub-rules (3) to (5);

(h) standard operating conditions and examples for developing other acceptable loading conditions using the information contained in the stability booklet;

(i) a brief description of the stability calculations done including assumptions;

(j) general precautions for preventing unintentional flooding;

(k) general precautions against capsizing and the responsibility of the master;

(l) vessels required to comply with damage stability criteria, information concerning the use of special cross-flooding fittings with descriptions of damage conditions which may require cross-flooding;

(m) other necessary guidance for the safe operation of the vessel under normal and emergency conditions;

(n) a table of contents and index for each booklet;

(o) inclining test report for the vessel, or:

(i) where the stability data is based on sister vessel, the inclining test report of that sister vessel along with the lightship measurement report for the vessel; or

(ii) where lightship particulars are determined by other methods than from inclining of the vessel or its sister, a summary of the method used to determine those particulars;

(p) recommendations for determination of the vessel's stability employing an in-service inclining test;

(q) in permanent ballast, location and weight of the vessel should be noted in the vessel's stability booklet, located such that it does not shift during the normal operation of the vessel and permanent ballast should not be removed fromthe vessel or relocated within the vessel without the approval of the designated authority.

(8) The alterations affecting stability are made, revised stability calculations shall be prepared and submitted for approvaland such revised stability information shall be re-approved by the designated authority.

(9) For Category 'B' and Category 'C' vessels, the provisions contained in sub-rules (1) to (8) shall apply only in so far as it is deemed reasonable, by the designated authority, considering the type, size and intended operational profile of the vessel.

**14. Damage stability.-** (1) Inland vessels may be required to show compliance with damage stability contained in these rules.

(2) Inland vessel to which the requirements of damage stability apply, there shall be permanently exhibited for the information of the officer in charge of the vessel, plans showing clearly for each deck and hold, the boundaries of the watertight compartments, the openings therein, the means of closing such openings, the position of the controls and the arrangements for the correction of any list due to flooding.

**15. Calculation of freeboard.–** (1) For all vessels, the assigned freeboard shall be the freeboard of the deepest approved loading condition recorded inthe intact or damage stability information booklets;

(2) Notwithstanding anything contained in sub-rule (1) the freeboard assigned shall in no case be less than 150 mm for cargo vessels and 300 mm for passenger vessels.

**16. Cargo hatches and conditions of assignment of freeboard.-** (1) The height of cargo hatch coamings above decks shall not less than:

(a) 300 [mm] for Zones 1 and 2; and

(b) 200 [mm] for Zone 3;

(2) In addition, the height of hatch coaming above load water line is to be not less than given in the Table below:

TABLE

| Height of Hatch coamings above load waterline | | | |
|---|---|---|---|
| | Zone 1 | Zone 2 | Zone 3 |
| With weathertight hatch cover | 1000 | 600 | 300 |
| Without weathertighthatch cover | 1700 | 1000 | 500 |

(3) For Category 'A' vessels, the type and strength of hatch-covers, where fitted, shall comply with the requirements **prescribed under** the Rules and Regulations for the Design and Construction of Steel Inland Vessels given at Annex-1 of this Rule for the vessels intended service and area of operation.

**17. Manholes.-** (1) Manholes on the weather decks are to be closed by substantial covers capable of closing them watertight.

(2) The strength and construction of manholes shall be commensurate with their location, and surrounding structure.

**18. Companionways, doors and accesses on weather decks.-** (1) Companionways on exposed deck are to be equivalent in strength and weather tightness to a deckhouse in the same portion and the height of the doorway sills above deck is not to be less than 100 [mm] for Zone 3 and 150 [mm] for Zone1 and 2 on exposed locations.

(2) For doorways directly leading to the engine room the sill height above deck shall not be less than 400 [mm].

(3) In addition, the sill heights above load waterline should not be less than the values mentioned below:

(a) Zone 1 - 1000 [mm];

(b) Zone 2 - 600 [mm];

(c) Zone 3 - 300 [mm].

**19. Openings on engine casing.-** (1) Machinery space openings shall have efficient closing appliances and the

openings and coamings for fiddley, funnel and machinery space ventilators in the casing shall be provided with strong covers of steel and other equivalent material permanently attached in their proper positions and capable of being secured weathertight.

(2) Skylights shall be of substantial construction and secured firmly to the deck and the following standards shall be complied with, namely:

(a) for skylights the coaming height is not to be less than the required height for hatch coamings;

(b) efficient means are to be provided for closing and securing the hinged scuttles;

(c) the thickness of glasses in fixed or opening skylights is to be appropriate to their position and size as required forside scuttles.

(d) glasses are to be protected against mechanical damage and shall be fitted with deadlights or storm covers permanently attached unless they are fitted at a height above waterline specified in sub-rule (2) of rule 16.

(3) Side scuttles in the engine casings shall be fitted with fireproof glass.

**20. Windows and side scuttles.-** (1) Side scuttles and windows shall be made and tested according to acceptable standards of Bureau of Indian Standards/orInternational Standards Organization**.**

(2) Side scuttles in the shell below freeboard deck are to be non-opening type with deadlights and the lower edge of glassis to be at least 500 [mm] above the load waterline in any condition of list or trim and such scuttles are to be adequately protected against damage by direct contact.

(3) However, heavy duty type windows or side scuttles conforming to Bureau of Indian Standards or International Standards Organization standards may be accepted without deadlights.

(4) Side scuttles and windows above deck may be fitted without deadlight or portable covers provided the height of lower edge of glass above waterline is not less than specified in Table below provided under this sub-rule:

**TABLE**

| Height of Side Scuttles [mm] | |
|---|---|
| Zone | Height [mm] |
| 1 | 1700 |
| 2 | 1000 |
| 3 | 500 |

(5) However, heavy duty typewindows or side scuttles conforming to Bureau of Indian Standards or International Standards Organization standards need not comply with the height requirement mentioned in sub- rule (4)

**21. Ventilators – general.-** (1) The scantlings of exposed ventilator coamings are to be equivalent to the scantlings of deckhouses in the same position**.**

(2) The ventilator trunks are to be well protected in cargo spaces and other areas where mechanical damage is likely to happen.

**22. Coaming heights.-** (1) Ventilators on exposed decks are to have the lower edge of openings at a height of not less than 300 [mm] above deck.

(2) In addition, the heights of lower edge of openings above waterline are to be not less than specified in Table below:

**TABLE**

| Ventilator Coaming Heights [mm] | | |
|---|---|---|
| | With closing appliances | Without closing appliances |
| Zone 1 | 1000 | 1700 |
| Zone 2 | 600 | 1000 |
| Zone 3 | 300 | 500 |

**23. Closing appliances.-** (1) Ventilator openings are to be fitted with efficient weathertight closing appliances, if applicable as specified in Table

provided under sub-rule (2) of rule 22.

(2) Ventilators not provided with weathertight closing appliances, or which are required to remain open for the continuousoperation of machinery, are to be taken as down-flooding points in stability calculations.

**24. Air and sounding pipes.-** (1) Arrangements shall be made to allow for ventilation and sounding of spaces intended to hold liquids, and any spacesnot easily accessible at all times**.**

(2) Sounding pipes shall lead above the freeboard deck to easily accessible places and shall have efficient means of closure and short sounding pipes are to be fitted with self-closing cocks.

(3) Notwithstanding anything contained in sub-rule (2), in machinery spaces and tunnels, when it is not possible to implement the requirement provided in sub-rule (2), the sounding pipes may lead above the deck into easily accessible places and when such sounding pipes serve tanks containing fuel or lubricating oil, they shall not lead near boilers, generators, electric motors or switchboards and shall be provided with automatic closing appliances.

(4) Sounding pipes may be replaced by a system of liquid filling level indicators.

(5) For tank spaces, air pipes shall also be provided to act as overflows leading above the freeboard deck.

(6) Sounding pipes shall be suitably protected throughout their length against damage and accidental shocks.

(7) Those sounding pipes passing through refrigerated spaces shall also be appropriately lagged.

(8) Precautions shall be taken to ensure that repeated soundings do not give rise to excessive local deterioration of plating.

(9) Striking plates of suitable thickness, or their equivalent, are to be fitted under all sounding pipes.

(10) The division, number and position of air pipes shall be arranged to avoid air locks and overpressure during fillingoperations and shall be arranged to avoid any accidental admission of water to the fuel tanks.

(11) The provision in sub-rule (10) shall apply to compartments situated outside the double bottom if they can be filled by a pumping system.

(12) Air and sounding pipes leading through cargo containment areas or other spaces where mechanical damage is likely to occur, are to be well protected.

**25. Height of air pipes.-** (1) The height of air pipes from the upper surface of decks exposed to the weather, to the point from where water mayhave access below, is not normally to be less than 300 [mm].

(2) The heights above load waterline of air pipes with and without closing appliances are not to be less than as specifiedin Table under sub-rule (2) of rule 22 for ventilators.

(3) Lower heights may be approved in cases where these are essential for the working of the vessel, provided closingappliances are of an approved automatic type.

(4) Air pipes not provided with weather tight closing appliances are to be taken as down-flooding points in stability calculations.

**26. Closing appliances for Sounding Pipes.-** (1) Permanently attached closing appliances are to be fitted in sounding pipes to prevent free entry of water.

(2) In case the closing appliances are not of an automatic type, provision is to be made for relieving vacuum when thetanks are being pumped out.

**27. Scuppers and sanitary discharges.-** (1) Scuppers sufficient in number and size to provide effective drainage are to be fitted in all-weather decks.

(2) Scuppers draining weather decks and spaces within superstructures or deckhouses not fitted with efficient weather tight doors are to be led overboard.

(3) Scuppers and discharges which drain spaces below the freeboard deck, or spaces within intact superstructures or deckhouses on the freeboard deck fitted with efficient weather tight doors, may be led to the bilges in the case of scuppersor suitable sanitary tanks in the case of sanitary discharges and alternatively, they may be led overboard:

Provided that the spaces drained are above the load waterline, and the pipes are fitted with efficient and accessible means of preventing water from passing inboard as required in sub-rule (1) of rule 26.

(4) Scuppers and discharge pipes should not pass-through fuel oil or cargo oil tanks and where scuppers and discharge pipes pass, unavoidably, through fuel oil or cargo oil tanks and should be led through the shell within the tanks, the thickness of the piping should be as thick as shell plating.

(5) All piping shall be adequately supported.

**28. Closing appliances for scupper and discharges.-** (1) Where the inboard end of scuppers and discharges are below main deck, normally a screw down non-return value inan accessible location is to be fitted to prevent water from passing inboard.

(2) Where the inboard end is above the main deck, a non-return valve is to be fitted at the shell, if the height of the inboardend above waterline is lower than the following:

(a) Zone 1 - 1000 [millimeters];

(b) Zone 2 - 600 [millimeters]; and

(c) Zone 3 - 300 [millimeters].

**29. Materials for valves, fittings and pipes.-** (1) All shell fittings and valves required under rule 26 & 28 are to be of steel, bronze or other approved ductile material;ordinary cast iron or similar material is not acceptable.

(2) Metals mentioned in sub-rule (1) made of steel or other approved material with low corrosion resistance, are to besuitably protected against wastage.

(3) The lengths of pipe attached to the shell fittings, elbow pieces or valves are to be of galvanized steel or other equivalentapproved material.

**30. Freeing ports for vessels operating in Zone-1.-** (1) For Vessels operating in Zone 1:-

(a) the minimum freeing port area on each side of the freeboard deck shall be given by the formula:

$A = 0.75\ (0.7 + 0.035l)$ square metres:

***Explanation*:** Where '*l*' is the length of the bulwark in the well or the length of the superstructure.

(b) the designated authority may consider it necessary to increase the freeing port area for any vessel.

(c) the lower edges of the freeing ports shall be at deck level or as near the deck as possible.

(2) Freeing ports over 300 millimeters in height shall be fitted with bars spaced not more than 230 millimeters apart orother appropriate protective appliances.

(3) If freeing ports are fitted with hinged shutters, ample clearance shall be provided to prevent jamming and hinge pinsor bearings shall be of non-corrodible material and such shutters shall not have locking appliances.

**31. Draught marks.-** (1) All Category 'A' vessels shall show on the bow and the stern, on each side, a draught scale, with 10 centimeter intervals, with figures of a height such that their complete submersion means an increase in draught of 10 centimeter and the accuracy of the draught marks shall be witnessed and confirmed by the designated authority.

(2) Draught marks on Category 'B' vessels shall be to the satisfaction of the designated authority.

**32. Freeboard marking.-** (1) Every vessel, to which a freeboard is assigned, shall be marked on each side of the vessel at amidships with its assigned freeboard and the marks shall consist of horizontal lines 25 millimeters in breadth and 300 millimeters in length.

(2) The location and accuracy of the freeboard mark shall be witnessed and confirmed by the designated authority and the freeboard mark shall be centered at amidships.

(3) In the event, the freeboard mark cannot be done as provided in sub-rule (2), for any reason it shallbe placed as near to that point as possible, and the distance of any deviation recorded.

(4) The freeboard marks shall be affixed under the control of the designated authority.

**33. Equipment of vessels - anchors, chain cables, mooring equipment and associated deck machinery. -**

(1) Every inland vessel shall be provided with anchors and chain cables as are sufficient in number and strength having regard to the size and intended service of the vessel.

(2) For Category 'A' vessels, the provision and testing of anchors, chain cables, chain lockers, mooring equipment, all associated deck fittings and deck machinery shall meet the requirements as **prescribed under** the Rules and Regulations for the Design and Construction of Steel Inland Vessels given at Annex-1 of this Rule. ~~of~~

(3) Category 'B' and 'C' vessels shall be provided with anchoring and mooring equipment following Bureau of Indian Standards or International Standards Organization and conform to industry best practice and such equipment shall commensurate with the size and type of vessel, and area of operation.

(4) In general, windlasses, capstans, winches, bollards, mooring posts and other means necessary for anchoring, mooring,towing or lifting the vessel shall be:

(a) designed to meet operating requirements and conditions that it may encounter;

(b) properly fitted; and

(c) fixed to a part of its structure with adequate strength.

(5) Inland vessels fitted with towing equipment shall meet the additional requirements specified in Chapter IV of these rules.

**34. Standards of fire protection.-** (1) The requirements shall apply to Category 'A' vessels and these provisions shall apply to Category 'B' and Category 'C' vessels, in so far as deemed reasonable by the designated authority, giving due consideration to their size and intended service.

Explanation: For the provisions on fire protection and escape as provided under these rules; wherever the words "steel or other equivalent material" occur, "equivalent material" means any non-combustible material which, by itself or due to insulation provided, has structural and integrity properties equivalent to steel at the end of the applicable exposure to the standard fire test.

(2) For the provisions on fire protection and escape as provided under these rules; 'Class A'- divisions are those divisions formed by bulkheads and decks shall comply with the following:

(a) they shall be constructed of steel or other equivalent material;

(b) they shall be suitably stiffened;

(c) they shall be constructed as to be capable of preventing the passage of smoke and flame to the end of the one- hour standard fire test;

(d) they shall be insulated with an approved non-combustible material such that the average temperature on the sidefacing away from the fire rises to not more than 140 °Celsius above the initial temperature and at no point, including the gaps at the joints, does a temperature increase of more than 180 °Celsius above the initial temperature occur withinthe following specified periods:

(i) **Class A 60** - 60 minutes;

(ii) **Class A 30** - 30 minutes; and

(iii) **Class A 0** - 0 minutes.

(3) Type 'B' partitions are bulkheads, walls, decks, ceilings that meet the following requirements:

(a) they are made of approved non-combustible material.

(b) furthermore, all materials used in the manufacture and assembly of partitions shall be non-combustible, except for the facing, which shall be at least flame retardant;

(c) they demonstrate an insulation value such that the average temperature on the side facing away from the fire risesto not more than 140 °Celsius above the initial temperature and at no point, including the gaps at the joints, does a temperature increase of more than 225 °Celsius above the initial temperature occur within the following specified periods:

(i) **Class B15** -15 minutes

(ii) **Class B 0** - 0 minutes;

(d) they are constructed in such a way as to prevent the transmission of flames until the end of the first half-hour of the standard fire test.

(4) "F" class divisions are those divisions formed by bulkheads, decks, ceilings and linings which comply with the following:

(a)they shall be constructed as to be capable of preventing the passage of flame to the end of the first half-hour of the standard fire test; and

(b)they shall have an insulation value such that the average temperature of the unexposed side will not rise more than 140°Celsius above the original temperature, nor will the temperature, at any one point, including any joint, rise more than 225°Celsius above the original temperature, to the end of the first half-hour of the standard fire test.

**35. Fire protection of machinery spaces.-** (1) All machinery spaces located under-deck or remote from the control position shall be fitted with a fire detection system comprising of smoke or heat detectors which will produce an audible alarm at the control position and consideration shall be given for waiver of this requirement in continuously manned machinery spaces.

(2) Decks and bulkheads divisions that separate machinery spaces from cargo spaces, accommodation, service areas, control stations vessel, shall be:

(a) of **Class A-30** class for vessels constructed of steel or equivalent material;

(b) specially considered for vessels constructed of aluminium alloys;

(c) of F class for vessels constructed of combustible materials.

(3) In the case of passenger vessels, boundary bulkheads of propulsion machinery spaces are to be of **Class A - 60** standard.

(4) A sub division may be accepted as equivalent to an 'F' class division if it consists of a combustible wall coatedwith a layer of 100 mm or two separate layers of 50 mm of mineral wool.

***Explanation1*:** The mineral wool shall have a density of at least 96 kg/m$^3$.

***Explanation 2*:** The external surface of the mineral wool shall be suitably protected against splashes of oil and otherflammable liquids.

(5) Doors and hatches of other openings in bulkheads shall be constructed such as to maintain the integrity of the bulkheads in which they are located.

(6) Pipes, ducts and controls which pass through a fire-resistant bulkhead shall not reduce its resistance to fire.

**36. Fire protection of accommodation areas.-** (1) In all enclosed accommodation the bulkheads, linings, ceilings and their associated grounds shall be constructed of non-combustible materials and their exposed surfaces shall have low flame spread.

(2) All vessels with passenger sleeping accommodation shall be fitted with a fixed fire detection system installed and arranged to detect the presence of fire in such spaces, as well as corridors, stairways and escape routes within accommodation areas.

(3) Appliances with naked flames or unprotected resistors for lighting and heating of accommodation shall not be used.

**37. Fire protection of galleys**. - (1) For cargo vessels, all galleys shall be enclosed by a Type A-0 standard steel boundary or equivalent, with self-closing steeldoors and for passenger vessels, bulkheads around galleys shall be of steel or equivalent material, and meeting a **Class A-30** standard; or of F class.

(2) Any serving hatches must be fitted with steel shutters.

(3) A readily accessible fire blanket is to be provided in the galley.

**38. Arrangements for combustible fuel, lubricating oil and other flammable oils. -** (1) In general, combustible liquid used as fuel shall have a flashpoint, determined by an approved test, more than 55°Celsius through Closed Crucible test, except in emergency generators, in which case the flashpoint shall be not less than 43°Celsius.

(2) Where oil fuel having a flashpoint of less than 55°C but not less than 43°C are used the conditions for use of such fuel as specified **prescribed under** the Rules and Regulations for the Design and Construction of Steel Inland Vessels given at Annex-1 of this Rule or by the Classification Society are to be complied with.

(3) When low flashpoint fuels are used, such vessels shall be considered as special category vessels, and are to comply with the requirements **prescribed under** the Rules and Regulations for the Design and Construction of Steel Inland Vessels given at Annex-1 of this Rule or of a Classification Society, which is a Member of International Association of Classification Societies and any additional provisions applicable to such vessels as prescribed by the CentralGovernment.

(4) Safe and efficient means of ascertaining the amount of fuel contained in any tank shall be provided.

(5) If such means consist of sounding pipes, their upper ends shall be located in safe positions and fitted with appropriate shutoff devices.

(6) Precautions shall be taken to prevent overpressure on fuel tanks including filling pipes and outlet valves and air or overflow pipes shall discharge the fuel into a safe place to avoid peril.

(7) Pumps of the oil fuel lines shall be separate from any other lines.

(8) No oil fuel tank shall be situated where spillage or leakage therefrom can constitute a hazard by falling on heated surfaces and precautions shall be taken to prevent any oil that may escape under pressure from any pump, filter or heaterfrom coming into contact with heated surfaces.

(9) Oil fuel pipes and connected valves and fittings shall be of steel or other approved material, except that the restricted use of flexible pipes may be permitted by the designated authority and such flexible pipes and end attachments shall be of approved fire-resisting materials or layered with fire-resisting coatings.

(10) Oil fuel lines shall be suitably protected to avoid oil spray or oil leakages onto hot surfaces or into machinery air intakes and the number of joints in such piping systems shall be kept in minimum.

(11) The arrangements for the storage, distribution and utilization of oil used in the pressure lubrication systems and otherflammable oils, shall be in accordance with the requirements as **prescribed under** the Rules and Regulations for the Design and Construction of Steel Inland Vessels given at Annex-1 of this Rule or of the classification society.

(12) Oil fuels, lubricating oils and other flammable oils shall not be carried in forepeak tanks and oil fuels shall not be stored forward of the collision bulkhead or its extension.

(13) Compartments intended to contain oil fuels with a flashpoint less than or equal to 55°Celsius but not less than 43°Celsius shall be insulated from continuous compartments intended for oil fuels with different flashpoints by cofferdams with air pipes and sounding pipes.

**39. Means of escape. -** (1) There should be at least two means of escape, as widely separated, from each section of normally occupied spaces and the designated authority may dispense with one of the means of escape for service spaces that are entered only occasionally, provided that the escape route does not pass through the galley, machinery space or watertight door.

(2) All escape routes are to be marked for effortless identification.

(3) In a passenger vessel, the sum of the width of all doors and passageways used as means of escape from a space shallnot be less than 5 millimeters multiplied by the number of passengers for which the space is designed with a minimum clear opening of not less than 800 millimetres and the doors of small passenger cabins shall have a clear opening not less than 700 millimeters.

**40. Bilge pumping arrangements. -** (1) The requirements of these rules generally apply to vessels of Category 'A', and the provisions shall apply to Category 'B' vessels, in so far as deemed reasonable by the designated authority, giving due consideration to their size and operational profile of the vessels.

(2) Inland vessels shall be provided with appliances for draining water from all compartments and bilges.

(3) Arrangements shall be made such that the water in the compartment concerned can flow freely to the suction outlet or outlets.

(4) Drainage from particular compartment considered undesirable may be omitted, provided it can be shown by calculations that the safety of the vessel will not be impaired.

(5) Category 'A' vessels shall comply with the bilge pumping standards **prescribed under** the Rules and Regulations for the Design and Construction of Steel Inland Vessels given at Annex-1 of this Rule or of Classification Societies appropriate for the type of service.

**41. Bilge pumps.-** (1) Category 'A' vessels with engine power exceeding 220 kilo Watts and passenger vessels shall be fitted with at least two power-driven bilge pumps, each powered by a different power source, one of which may be driven by the propulsionmachinery**.**

(2) At least one power driven pump shall be provided in vessels with engine power up to 220 kilowatts driven by the main engine and in addition, hand pump suctions are to be fitted.

(3) In passenger vessels, the bilge pumps are to be placed in separate watertight compartments and suction pipes shall be arranged so that any compartment can be effectively drained.

*Explanation*: One bilge pump may be the fire pump complying with the relevant firefighting requirements.

(4) Bilge pumps provided for peak spaces and chain lockers shall be hand pumps, operated from a point located above the freeboard deck.

(5) Each bilge pump shall be placed aft of the collision bulkhead and placed to pump water from any compartment except as specified in sub-rule (4) and special appliances shall be installed to start the pumps.

(6) Bilge pump installed shall be of self-priming type.

**42. Bilge pipes. -** (1) The arrangement of the bilge and ballast pumping systems shall be such as to prevent the possibility of water passinginto the compartments of the vessel or from one compartment to another.

(2) In machinery spaces, bilge pipes and accessories shall be of steel or any other material the characteristics of which are accepted as equivalent for the intended application.

(3) The pumping systems in machinery spaces or cargo holds shall be completely separate from sea inlet pipes or from pipes normally used for filling or emptying compartments intended to hold water or liquid fuel.

(4) Bilge suction piping up to the connection to the pumps shall be independent of other piping and all bilge pipes shall be of steel or equivalent material.

(5) Bilge suction pipes shall not be led through oil tanks except in the case of double bottom tanks, and in case of bilge suction pipes passing through freshwater tanks, such pipes shall be of heavy gauge and pipe joints shall be of the fully welded type and the number of pipe joints shall be kept to a minimum.

(6) The diameter of the bilge main shall satisfy the requirements of the rules **prescribed under** the Rules and Regulations for the Design and Construction of Steel Inland Vessels given at Annex-1 of this Rule or the requirements acceptable to the designated authority in the case of category 'C' vessels.

**43. Direct suction by pumps.-** (1) In the machinery compartment, a suction duct shall be directly connected to a bilge pump.

(2) The diameter of the duct shall be atleast equal to that of the bilge main.

(3) Direct suction shall be through fixed pipe or reinforced flexible hose, in case, the suction is through a fixed pipe,it shall be placed as low as possible; in a way accessible for cleaning and fitted with a non-return valve.

(4) In the case of passenger vessels, each independent power bilge pump shall have a direct suction from the space where it is situated:

Provided that not more than two direct suctions shall be required in one space and where two or more such suctions are provided in a single space, they shall be positioned on either side of the vessel or space.

**44. Bilge system accessories. -** (1) In passenger vessels, all distribution boxes and valves fitted in connection with the bilge pumping arrangements shallbe in positions which are accessible at all times in ordinary circumstances and if in any such vessel there is only one system of pipes common to all such pumps, the necessary valves for controlling the bilge suctions shall be capable of being operated from above the vessel's freeboard deck.

(2) In passenger vessels, every valve which is required by these rules to be operated from above the freeboard deck shall have its control, at its place of operation, clearly marked to show the purpose it serves and how it may be opened and closed and it shall be provided with a means to indicate whether it is open or closed.

(3) Suction ducts shall, as far as possible, be placed at the lowest points in the corresponding compartments and they shall be fitted with grills of substantial construction, placed in a readily visible location and cleaned, without it being necessary to first dismantle the connections in the suction ducting.

**45. Plan of the bilge-pump and water drainage system. -** (1) A detailed plan of the bilge pump system shall be clearly exhibited in a place where personnel can read it easily.

(2) The graphic symbols used shall conform to standards in force unless the meaning of the symbols used is clearly indicated.

(3) Scuppers or appropriate arrangements shall be provided in areas of the vessel where water is likely to accumulate dangerously during fire-fighting operations.

**46. Alternative arrangements for small vessels. -** For inland vessels of less than 24 metres in length, where the fitting of a bilge main is not practical, the requirements of this rule may be satisfied by the use of individual submersible pumps.

**47. General Rules of Machinery. -** (1) The inland vessel must comply with the relevant machinery standards of the requirements prescribed under **the Rules and Regulations for the Design and Construction of Steel Inland Vessels given at Annex-1 of this Rule** or the requirements acceptable to the designated authority in the case of Category 'C' vessels, suitable for the vessel type and its operational profile; and the minimum requirements for machinery specified in this rule shall not be construed as an alternative to full compliance with the requirements prescribed under **the Rules and Regulations for the Design and Construction of Steel Inland Vessels given at Annex-1 of this Rule.**

(2) The ambient reference conditions shall be of that the rating of the main and auxiliary machinery is to be suitable for the temperature conditions associated with the geographical limits of the restricted service.

(3) Machinery installations are to be designed such as to ensure proper operations under the conditions as under:

(a) list of 10°;

(b) trim of 5°.

**48. Machinery requirements.-** (1) The machinery, boilers and other pressure vessels, associated piping systems and fittings shall be of a design and construction adequate for the service for which they are intended and shall be so installed and protected as to reduce to a minimum any danger to persons on board, with due regard being paid to moving parts, hot surfaces and other hazards and the design shall have regard to the materials used in construction, the purpose for which the equipment is intended, the working conditions to which it will be subjected and the environmental conditions on board.

(2) All boilers, all parts of machinery, all steam, hydraulic, pneumatic and other systems and their associated fittings which are under pressure shall be subjected to appropriate tests including a pressure test before being put into service forthe first time.

(3) Means shall be provided to ensure that the machinery can be brought into operation from the dead vessel condition without external aid.

(4) Provision shall be made to facilitate cleaning, inspection and maintenance of main propulsion and auxiliary machinery including boilers and pressure vessels.

(5) Where risk from over speeding of machinery exists, means shall be provided to ensure that the safe speed is not exceeded.

(6) Where main or auxiliary machinery, including pressure vessels or any parts of such machinery, are subject to internal pressure and may be subject to dangerous overpressure, means shall be provided where practicable to protect against such excessive pressure.

(7) All gearing and every shaft and coupling used for transmission of power to machinery essential for the propulsion and safety of the vessel or the safety of persons on board shall be so designed and constructed that they shall withstand the maximum working stresses to which they may be subjected in all service conditions.

(8) Main propulsion machinery and auxiliary machinery shall be provided with automatic shut-off arrangements in the case of failures such as lubricating oil supply failure which could rapidly lead to complete breakdown, serious damageor explosion.

(9) Internal combustion engines of a cylinder diameter more than 200 millimeters or a crankcase volume of at least 0.6 cubic metres shall be provided with crankcase explosion relief valves of a suitable type with a sufficient relief area and the relief valves shall be arranged or provided with means to ensure that the discharge from them is so directed as to minimize the possibility of injury to personnel.

**49. Machinery controls. -** Main and auxiliary machinery essential for the propulsion and safety of the vessel shall be provided with effective meansfor its operation and control.

**50. Remote control of propulsion machinery. -** Where remote control of propulsion machinery from the navigation bridge is provided, the speed, direction of thrust andif applicable, the pitch of the propeller shall be fully controllable from the navigation bridge under all sailing conditions,including manoeuverings.

**51. Ventilating systems in machinery spaces. -** (1) All machinery spaces shall be adequately ventilated, ensure that when the machinery or boilers therein are operating at full power in all weather conditions, under adequate supply of air is maintained to the spaces for thesafety and comfort of personnel and the operation of the machinery.

(2) In addition, the ventilation of machinery spaces shall be adequate, under normal conditions, to prevent the accumulation of hydrocarbon vapour.

**52. Protection against noise. -** (1) Measures shall be taken to reduce machinery noise in machinery spaces to acceptable levels and if this noise cannot be sufficiently reduced, the source of the excessive noise shall be suitably insulated or isolated, or a refuge from noise shallbe provided if the spaces are required to be manned.

(2) Ear protectors shall be provided for personnel required to enter suchspaces.

**53. Means of manoeuvring and going astern. -** (1) Sufficient power for going astern shall be provided to secure proper control of the vessel in all normal circumstances.

(2) The ability of the machinery to reverse the direction of thrust of the propeller within sufficient time and so to bring the vessel to rest within a reasonable distance from maximum ahead service speed, shall be demonstrated and recorded.

(3) The stopping times, vessel headings and distances recorded on trials, shall be available onboard for the use of the master or designated personnel.

(4) The effective operation of any supplementary means of stopping or manoeuverings the vessel shall be demonstrated and recorded

**54. Steering** gear. **-** (1) Every inland vessel of Category 'A' shall be provided with a main steering gear and an auxiliary steering gear and the main steering gear and the auxiliary steering gear shall be so arranged that the failure of one of them will not render the other one inoperative.

(2) The auxiliary steering gear shall be capable of being rapidly brought into action and shall be of adequate strength and of sufficient power to enable the vessel to be steered at navigable speed.

(3) Category 'B' and Category 'C' vessels are to be provided with reliable steering systems. In the case of Category 'C' vessels, only a hand tiller may be provided for steering, if acceptable to the designated authority. If a fully powered steering gear is fitted in Category 'B' and Category 'C' vessels, an independent secondary means of steering is to be provided.

(4) Communication devices shall be provided to enable orders to be transmitted from the bridge to any alternative steering position.

(5) Steering systems shall comply with the following requirements:

(a) for manually controlled steering systems, a single turn of the wheel shall correspond to a rudder angle of at least 3°;

(b) for powered steering systems, when the rudder is at maximum immersion, it shall be possible to achieve an averageangular velocity of 4°/s over the rudder's entire turning range.

(6) This requirement shall also be checked, with the vessel at full speed, for moving the rudder over a range from 35° port to 35° starboard.

(7) In addition, it shall be checked whether the rudder keeps the position of the maximum angle at maximum propulsion power.

(8) For other types of steering systems, these requirements are to be correspondingly applied.

**55. Engineers' alarm.-** In case of vessels with periodically unattended engine rooms, an engineer's alarm shall be operated from the enginecontrol room or at the manoeuvring platform as appropriate, and shall be clearly audible in the engineers accommodation:

Provided that the designated authority may exempt any vessel of less than 1000 GT and carrying less than hundred passengers from this requirement if it considers that such an alarm is not necessary taking into account the proximity of the engine control room or station to the engineers' accommodation.

**56. Means for stopping machinery, shutting off flammable oil supply pipes, pumps and closing of openings.-** (1) Means shall be provided -

(a) for stopping ventilating fans serving machinery and accommodation spaces;

(b) for closing all doorways, ventilators, and other openings to such spaces; and

(c) to permit the release of smoke from machinery spaces.

(2) Means provided under sub-rule (1) shall be capable of being operated from positions outside the spaces and which would not be made inaccessible by a fire within such spaces.

(3) Means shall be provided for shutting off fuel, lubricating oil, hydraulic oil supplies, and associated pumps and shall be readily accessible, situated outside the machinery space and shall be clearly labelled.

(4) The means of stopping machinery, shutting off flammable oil supply pipes, pumps and closing of openings, for other types of propulsion shall be considered.

**57. Fuel and associated pipework.-** (1) Oil fuel lines shall not be located immediately above or near units of high temperature, including boilers, steampipelines, exhaust manifolds, silencers and as far as practicable, oil fuel lines shall be arranged apart from hot surfaces, electrical installations or other sources of ignition and shall be screened or otherwise suitably protected to avoid oil sprayor oil leakage onto the sources of ignition.

(2) Components of a diesel engine fuel system shall be designed considering the maximum peak pressure which shall be experienced in service, including any high-pressure pulses which are generated and transmitted back into the fuelsupply and spill lines by the action of fuel line injection pumps and the connections within the fuel supply and spill lines shall be constructed having regard to their ability to prevent pressurised oil fuel leaks while in service and after maintenance.

**58. Flexible fuel pipes.-** (1) Minimum length of flexible hoses may be used where necessary to allow for relative movements and vibration between machinery and fixed piping systems and the hoses and any couplings shall be suitable for the intended purpose.

(2) Documentary evidence shall be provided to show that the pipework complies with the Bureau of Indian Standards or International Standards Organization standards.

(3) Flexible fuel pipework shall be installed in accordance with the manufacturer's instruction and correctly supported.

(4) The pipework shall be provided with sufficient free movement to accommodate vibration and to avoid contact with any structure and where protective sleeves are fitted, the sleeve shall be extended beyond the length of the pipe, with appropriateleak proof end connections.

(5) Flexible fuel pipework shall be renewed according to the pipe manufacturer's instructions and records of the most recent pipe renewal shall be kept onboard and ashore.

**59. Electrical equipment and installations.-** (1) Electrical equipment and installations of all mechanically propelled inland vessels shall comply with the relevant electrical standards prescribed under **the Rules and Regulations for the Design and Construction of Steel Inland Vessels given at Annex-1 of this Rule** or of the Classification Society or other National or International Standards which provide an equivalent level of safety; and the standards included in these rules specify minimum requirements that shall be satisfied.

(2) The electrical equipment and installations (including any electrical means of propulsion) shall be such that the vessel and all persons onboard are protected against electrical hazards.

(3) The electrical equipment and installations shall be maintained to ensure the vessel is in an operational and habitable condition.

(4) The main source of electrical power shall be capable of illuminating any part of the vessel normally accessible to and used by the passengers or crew.

(5) Electrical services essential for safety shall be ensured under various emergency conditions.

(6) All exposed metal parts of electrical machines or equipment which are not intended to be live but which are liable under fault conditions to become live shall be earthed unless the machines or equipment are:

(a) supplied at a voltage not exceeding 55 V direct current or 55 V root mean square between conductors. Auto-transformers shall not be used for the purpose of achieving this voltage; or

(b) supplied at a voltage not exceeding 250 V by safety isolating transformers supplying only consuming device; or

(c)constructed in accordance with the principle of double insulation.

(7) Electrical circuits shall be provided with adequate protection against short circuit and overload.

(8) Accumulator batteries shall be suitably housed, and compartments used primarily for their storage shall be properly constructed and efficiently ventilated and they shall not be stored in sleeping quarters.

(9) No electrical equipment shall be installed in any space where flammable mixtures are liable to collect including those on-board tankers or barges carrying flammable liquids in bulk or in compartments assigned primarily to accumulator batteries, in paint lockers, acetylene stores or similar spaces, unless the designated authority is satisfied that such equipment is—

(a) essential for operational purposes;

(b) of a type which will not ignite the mixture concerned;

(c) appropriate to the space concerned; and

(d) appropriately certified for safe usage in the dusts, vapour or gases likely to be encountered.

(10) Lightning conductors shall be installed on masts and mastheads constructed with non-conducting materials.

(11) If the vessel is constructed with non-conducting materials, the lightning conductors shall be connected to copper plates fitted to the vessel's hull and running well below the water line.

**60. Electrical cables.-** (1) All electric cables and external wiring to the equipment shall be at least of flame-retardant type.

(2) Cables and wiring which is serving essential or emergency power, lighting, internal communications or signals shall be routed clear of galleys, laundries, machinery spaces and their housings and other high fire risk areas.

(3) Where cables which are installed in hazardous areas introduce the risk of fire or explosion in the event of an electrical fault in such areas, special precautions against such risks shall be taken such as are considered necessary by designated authorities.

(4) Cables and wiring shall be installed and supported in such a manner so as to avoid chafing or other damage.

(5) Terminations and joints in all conductors shall be so made as to retain the original electrical, mechanical, flame-retarding and, where necessary, fire-resisting properties of the cable.

**61. Stores, spare Gear and Tools.-** Every inland vessel shall be provided with stores, spare gear and tools as may be necessary and sufficient for the intendedservice of the vessel.

## CHAPTER IV

## SPECIAL PROVISIONS APPLICABLE TO PASSENGER VESSELS

**62. Application and stability rules. -** (1) The requirements under this rule shall apply to decked Category 'A' passenger vessels, which carries more than 50 passengers and these provisions shall be applied to vessels of Category 'B' and Category 'C', in so far as they are considered reasonable and practicable, by the designated authority.

(2) Alternatively, vessels of Category 'B' may comply with the requirements of ISO 12217-1 and vessels of Category 'C' of less than 6 metres in length may comply with the requirements of ISO 12217-3 for stability and buoyancy.

(3) The intact stability shall be proven for the following standard loading conditions—

(a) at the start of the voyage:100 % passengers, 98 % fuel and fresh water, 10 % waste water;

(b) during the voyage:100 % passengers, 50 % fuel and fresh water, 50 % waste water;

(c) at the end of the voyage:100 % passengers, 10 % fuel and fresh water, 98 % waste water;

(d) unladen vessel: no passengers, 10 % fuel and fresh water, no waste water.

***Explanation:*** For all standard loading conditions, the ballast tanks shall be considered as either empty or full inaccordance with normal operational conditions.

(4) In addition, the requirements of clause (d) of sub-rule (3) of this rule are to be proved for the loading condition involving 100% Passengers, 50% fuel and fresh water, 50% waste water, all other liquid (including ballast) tanks are considered filled to 50%.

(5) Stability calculations for additional loading conditions may need to be submitted, in case it is necessary to verify thesafety of the vessel.

(6) The proof of adequate intact stability by means of a calculation is to be produced using the following definitions forthe intact stability and for the standard loading conditions mentioned in sub-rule (3) and sub-rule (4):

(a) the maximum righting lever $hmax$ is to occur at a heeling angle of $\varphi max \geq(\varphi mom$+3°) and is not to be less than 0.2[m]. However, in case $\varphi f<\varphi max$ the righting lever at the down flooding angle $\varphi f$ is not to be less than 0.2 [m];

(b) the down flooding angle $\varphi f$ is not to be less than ($\varphi mom$+3°);

(c) the area $A$ under the curve of the righting levers is to, depending on the position of $\varphi f$ and $\varphi max$, reach at leastthe following values mentioned in the table below:

**TABLE**

| Intact Stability Criteria | | | |
|---|---|---|---|
| Case | | | Area |
| 1 | $\varphi max \leq 15^\circ$ or $\varphi f \leq 15^\circ$ | | 0.05 [m.rad] up to the smaller of the angles $\varphi max$ or $\varphi f$ |
| 2 | $15^\circ < \varphi max < 30^\circ$ | $\varphi max \leq \varphi f$ | 0.035 + 0.001 (30 - $\varphi max$) [m.rad] up to the angle $\varphi max$ |
| 3 | $15^\circ < \varphi f < 30^\circ$ | $\varphi max > \varphi f$ | 0.035 + 0.001 (30 - $\varphi f$) [m.rad] up to the angle $\varphi f$ |
| 4 | $\varphi max \geq 30^\circ$ and $\varphi f \geq 15^\circ$ | | 0.035 [m.rad] up to the angle $\varphi=30^\circ$ |

*Explanation.—*

Where,

$h_{max}$: is the maximum lever$\varphi$ : the heeling angle;

$\varphi f$ : the down flooding angle, that is the heeling angle, at which openings in the hull, in the superstructure or deck houses which cannot be closed so as to be weathertight , submerge;

$\varphi_{mom}$ : the maximum heeling angle according to e);

$\varphi_{max}$ : the heeling angle at which the maximum righting lever occurs;

A: the area under the curve of the righting levers.

(d) the initial metacentric height, $GMo$, corrected by the free surface effect in liquid tanks, is not to be less than 0.15[m];

(e)in each of the following two cases the heeling angle $\varphi mom$ is not to exceed 12°:

(i) in application of the heeling moment due to persons and wind according to Rules 63 and 64;

(ii) in application of the heeling moment due to persons and turning according to Rules 63 and 65

(f) for a heeling moment resulting from moments due to persons, wind and turning according to Rules 63, 64 and 65, the residual freeboard is to be not less than 0.2 [m];

(g) for vessels with windows or other openings in the hull located below the bulkhead decks and not closed watertight, the residual safety clearance is to be at least 0.1 [m] on the application of the three heeling moments resulting from (f) above.

**63. Heeling moment due to accumulation of persons.-** (1) The heeling moment Mp [kN-m], caused by accumulation of persons on one side of the vessel, is the sum of individual heeling moments on various decks occupied by passengers, and, is to be calculated according to thefollowing formula:

(a) $M_p = g\ P\ y = g\ \sum P_i\ y_i\ [kNm]$

*Explanation* 1.—

P = total mass of persons on board in [t], calculated by adding up the maximum permitted number of passengers andthe maximum number of shipboard personnel and crew under normal operating conditions, assuming an average massper person of 0.075 [t]

y = lateral distance of center of gravity of total mass of persons P from Centre line in [m]g = acceleration of gravity ( g = 9.81 [m/s2])

Pi = mass of persons accumulated on area Ai ;

(b) $P_i = n_i\ 0.075\ A_i\quad [t]$

*Explanation* 2.—Where,

Ai = area occupied by the persons in [m2]ni = number of persons per square meter:

ni = 3.75 for free deck areas; for deck areas with fixed seating furniture such as benched, ni is to be calculated byassuming as area of 0.5 [m] in width and 0.75 [m] in seat depth per person.

yi = lateral distance of geometrical Centre of area Ai from Centre line in [m]

(2) The calculation is to be carried out for accumulation of persons both to starboard and to the port.

(3) The distribution of persons shall correspond to the most unfavourable one from the point of view of stability and cabins are to be assumed unoccupied for the calculation of the persons' moment.

(4) For the calculation of the loading cases, the Centre of gravity of a person is to be taken as 1 [m] above the lowest point of the deck at 0.5 Lwl, ignoring any deck curvature and assuming a mass of 0.075 [t] per person.

(5) A detailed calculation and plan of deck areas which are occupied by persons may be dispensed with, if the valueof y is considered as 0.45 of the breadth.

**64. Heeling moment due to Wind.-** (1) The heeling moment due to wind pressure Mw is to be calculated as follows:

$$M_w = p_w A_w \left(L_w + \frac{T}{2}\right)\ [kNm]$$

***Explanation:***

Where:

$pw$ = 0.25 [kN/m²];

However, the value for pw may be taken as per actual prevailing wind conditions in the relevant service area of the vessel and not less than 0.1 [kN/m2]. Any operating restrictions are to be indicated in the Stability Booklet and the Certificate of Survey."

$Aw$= lateral plane of the vessel above the plane of draught according to the considered loading condition in [m²];

L$w$ = distance of the Centre of gravity of the lateral plane $Aw$ from the plane of draught according to the considered loading condition in [m].

(2)In calculating the lateral plane, account is to be taken of the intended enclosure of the deck by awnings and similar mobile installations.

**65. Heeling moment due to turning.-** (1) The moment due to centrifugal force $Mdr$, caused by the turning of the vessel, is to be calculated as follows:

$$M_{dr} = c_{dr} C_B v^2 \frac{D}{L_{WL}} \left( KG - \frac{T}{2} \right) \; [kNm]$$

*Explanation.*—Where,

$Cdr$ = a coefficient of 0.045;

$CB$ = block coefficient (if not known, taken as 1.0);

$v$ = maximum speed of the vessel in [m/s];

$KG$ = distance between the Centre of gravity and the keel line in [m].

(2) For passenger vessels with rudder-propeller, water-jet, cycloidal-propeller and bow-thruster propulsion systems,

$Mdr$ is to be derived from full-scale or model tests or else from corresponding calculations.

**66. Damage stability.-** (1) It is to be proved by calculation that the damage stability of the vessel is appropriate and the calculation of the final stage of flooding shall be based on the method of "lost buoyancy" and the interim states of flooding should be calculated on the basis of the method of "added mass".

*Explanation.* — All calculations are to be carried out free to trim and sinkage.

(2) Buoyancy of the vessel in the event of flooding is to be proven for the standard loading conditions specified in sub-rule (3) of rule 62 and accordingly, mathematical proof of sufficient stability is to be determined for the three intermediate stages of flooding (25, 50 and 75 % of flood build-up) and for the final stage of flooding.

(3) Passenger vessels are to comply with the one-compartment status and the two-compartment status.

(4) The following assumptions in table below concerning the extent of damage are to be taken into account in the event of flooding—

**TABLE**

| Extent of damage | | |
|---|---|---|
| | One-Compartment Status | Two-Compartment Status[2] |
| Dimension of the side damage | | |
| Longitudinal l [m] | 0.10 LWL , however not less than 4 [m][3] | 0.05 LWL , however not less than 2.25 [m] |
| Transverse b [m] | B/5 | 0.59 |
| Vertical h [m] | From vessel bottom to top without delimitation | |
| Dimension of the bottom damage | | |
| Longitudinal l [m] | 0.10 LWL , however not less than 4 [m][3] | 0.05 LWL , however not less than 2.25 [m] |
| Transverse b [m] | B/5 | |
| Vertical h [m] | 0.59; pipework are to be deemed intact[1] | |

1) Where a pipework system has no open outlet in a compartment, the pipework shall be regarded as intact in the event of this compartment being damaged, if it runs within the safe area and is more than 0.50 [m] off the bottom of the vessel.

2) Passenger vessels with a length $L$ of not more than 45 [m] and authorized to carry up to a maximum of 250 passengers do not need to have 2 compartment status.

3) For vessels less than 24 m in length, this value may be taken as "0.10 LWL"

(a) for One-compartment status the bulkheads can be assumed to be intact if the distance between two adjacent bulkheads is greater than the damage length and longitudinal bulkheads at a distance of less than B/3 to the hull,measured perpendicular to the Centre line from the shell plating at the maximum draft are not to be taken into account for calculation purposes.

***Explanation*:** A bulkhead recess in a transverse bulkhead that is longer than 2.5 [m], is considered a longitudinalbulkhead.

(b) for Two-compartment status each bulkhead within the extent of damage will be assumed to be damaged and thismeans that the position of the bulkheads is to be selected in such a way as to ensure that the passenger vessel remains buoyant after flooding of two or more adjacent compartments in the longitudinal direction.

(c ) the lowest point of every non-watertight opening (e.g. doors, windows, access hatchways) is to lie at least 0.1

[m] above the damaged waterline and the bulkhead deck is not to be immersed in the final stage of flooding.

(d) permeability is assumed to be 95 %. If it is proven by a calculation that the average permeability of any compartment is less than 95 %, the calculated value can be used instead. The values to be adopted are not to be less than those indicated in the below Table:-

**TABLE**

| Permeability Values | |
|---|---|
| Lounges | 95% |
| Engine and boiler room | 85% |
| Luggage and store room | 75% |
| Double bottoms, fuel bunkers, ballast and other tanks, depending on whether, according to their intended purpose, they are to be assumedto be full or empty for the vessel floating at the plane of maximum draught | 0% or 95% |

(e) if damage of a smaller dimension than specified above produces more detrimental effects with respect to heeling or loss of metacentric height, such damage is to be taken into account for calculation purposes.

(5) For all intermediate stages of flooding referred to in sub rule (2), the following criteria shall be met:

(a) the heeling angle $\varphi$ at the equilibrium position of the intermediate stage in question is to not exceed 15°.

(b) beyond the heel in the equilibrium position of the intermediate stage in question, the positive part of the righting lever curve is to display a righting lever value of $GZ \geq 0.02$ $[m]$ before the first unprotected opening becomes immersed or a heeling angle $\varphi$ of 25° is reached.

(c ) non-watertight openings are not to be immersed before the heel in the equilibrium position of the intermediate stage in question has been reached.

(d) the calculation of the free surface effect in all intermediate stages of flooding is to be based on the gross surface area of the damaged compartments.

(6) During the final stage of flooding, the following criteria are to be met taking into account the heeling moment in accordance with Rule 62

(a) the heeling angle $\varphi E$ is to not exceed 10°.

(b) beyond the equilibrium position the positive part of the righting lever curve is to display a righting lever valueof $GZR \geq 0.02$ $[m]$ with an area $A \geq 0.0025$ $[m \cdot rad]$ and these minimum values for stability are to be met until the immersion of the first unprotected opening or in any case before reaching a heeling angle of 25°.

(c) non-watertight openings are not to be immersed before the equilibrium position has been reached and if such openings are immersed before this point, the rooms affording access are deemed to be flooded for damage stability calculation purposes.

(d) the shut-off devices which are to be able to be closed watertight are to be marked accordingly.

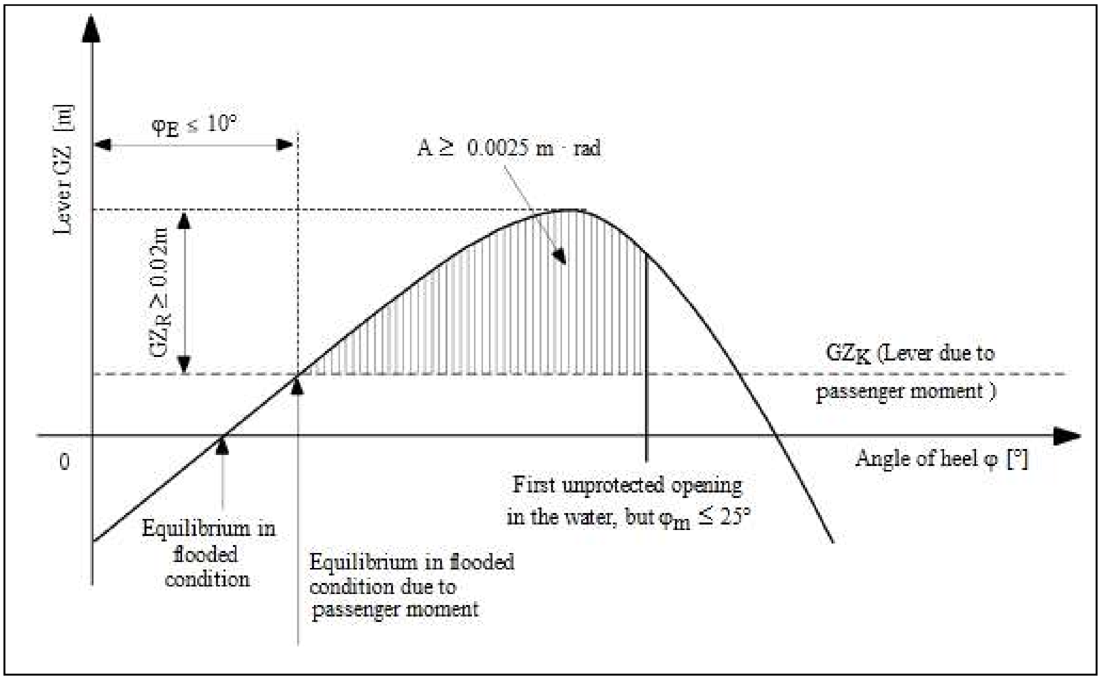



Figure Damage Stability

(7) Passenger vessels authorised to carry up to a maximum of 50 passengers and with a length of not more than 25 (m) are to prove adequate stability after damage as per sub-rules (1) to (5) or, as an alternative, prove that they comply withthe following criteria after symmetrical flooding of the entire vessel—

(a) the immersion of the vessel is not to exceed the margin line (notional line drawn on the shell 100 [mm] below thetop of the bulkhead deck at side. Where, in a part of the ship, the bulkhead deck is stepped below or not fitted, the margin line is to be drawn 100 [mm] below the level up to which both the transverse bulkheads and side shell are watertight); and

(b) the residual metacentric height $GMR$ is not to be less than 0.10 [m].

(8) The necessary residual buoyancy is to be assured through the appropriate choice of material used for the construction of the hull or by means of highly cellular foam floats, solidly attached to the hull.

(9) In the case of vessels with a length of more than 15 [m], residual buoyancy can be ensured by a combination of floats and subdivision complying with the One- compartment status.

**67. Cross flooding arrangements.-** (1) If cross-flood openings to reduce asymmetrical flooding are provided, they have to meet the following conditions, namely:

(a) for the calculation of cross-flooding, IMO Resolution MSC.245(83) is to be applied;

(b) they are to be self-activating;

(c) they are not to be equipped with shut-off devices;

(d) the total time allowed for compensation is not to exceed 15 minutes.

**68. Watertight integrity.-** (1) Watertight doors in bulkheads which normally remain open are to be fitted with local controls on either side of the bulkhead and remote control in an accessible place above the bulkhead deck and the following requirementsare also to be complied with:

(a) the remote control is to be fitted with an indicator showing whether the door is open or closed;

(b) in addition, indicators are to be fitted in the wheelhouse, showing whether these doors are open or closed;

(c) an automatic audible alarm is to be fitted at the door, sounding during the closing of the door;

(d) the operation of watertight doors and automatic alarms is to be possible independent from the vessel's normalelectrical system; and

(e) the closing time of the doors is to be not less than 30 seconds and not more than 60 seconds.

(2) Watertight doors, which are not remotely operated are permitted, only in those spaces which are not accessible to passengers.

(3) Such doors are to be kept closed and may only be opened for passage and are to be closed again immediately.

(4) All watertight doors with their local and remote controls as well as alarm arrangements are to be located inboard of the assumed transverse extent of damage.

(5) Piping systems and ventilation ducts with open ends are to be so arranged that flooding of the compartment under consideration shall not result in the flooding of any other space or tank.

(6) Where several compartments are in open connection through pipe lines or ventilation ducts, the pipes and ducts are to be led through the watertight bulkheads, above the water line in the most unfavourable conditions of flooding.

(7) Where this is not possible, valves which are remotely controlled from above the bulkhead deck are to be fitted at the watertight bulkheads.

(8) When a pipe system has no open end in a compartment, this pipe line shall be considered undamaged in the case of flooding of that compartment provided it is situated inboard of the assumed transverse extent of damage and 0.5 [m] above the vessels bottom.

(9) Cables which are to pass through watertight bulkheads are to be so arranged that the watertight integrity of the bulkheads is not impaired.

(10) All watertight portlights to be fitted below the damaged waterline are to be of the non-opening type and of adequate strength and fitted with deadlights.

(11) No window is to be fitted below the damaged waterline.

**69. Emergency power.-** (1) Every inland passenger vessel shall be provided with an emergency power supply for the following things:

(a) navigation lights;

(b) audible warning devices;

(c) emergency lighting;

(d) fixed Very High Frequency installations;

(e) alarm and public address systems;

(f) searchlights;

(g) fire alarm system;

(h) other safety equipment such as automatic pressurised sprinkler systems or fire pumps;

(i) emergency bilge pumping systems;

(j) electronically powered signage where fitted; and

(k) survival craft launching system, where appropriate.

(2) The following are admissible for use as an emergency power source—

(a) auxiliary generator sets with their own independent fuel supply and independent cooling system which, in the event of a power failure, start and take over the supply of power within 45 seconds automatically or, if they are located in the immediate vicinity of the wheelhouse or any other location permanently manned by crew members, can be brought into operation within 45 seconds; or

(b) accumulator batteries, which, in the event of a power failure, connect automatically or, if they are located inthe immediate vicinity of the wheelhouse or any other location permanently manned by crew members, can be connected manually;

(c) they shall be capable of powering the items listed in sub-rule (1) above, without rechargingand without an unacceptable voltage reduction throughout the projected operating period; and

(d) the projected operating period for the emergency power supply shall not be less than 60 minutes.

(3) In the case of vessels of length 24 m and above, the emergency power source and any associated switchboard plant shall be in a separate space to the main power supply and cables feeding the electrical installations in the event of an emergency shall be installed and routed in such a way as to maintain the continuity of supply of these installations in theevent of fire or flooding;

(4) Such cables shall never be routed through the main engine room, galleys or space where themain power source and connected equipment is installed, except where necessary to provide emergency equipment in such areas.

(5) The emergency power source shall be installed above the line of the bulkhead deck of sub divided vessels and as high as possible in open vessels.

(6) For the following rooms and locations, emergency lighting shall be provided:

(a) locations where life-saving equipment is stored and where such equipment is normally prepared for use;

(b) escape routes, access for passengers, including gangways, entrances and exits, connecting corridors,

lifts andaccommodation areas companionways, cabin areas and accommodation areas;

(c) markings on the escape routes and emergency exits;

(d) in other areas intended for use by persons with reduced mobility;

(e) operation rooms, engine rooms, steering equipment rooms and their exits;

(f) wheelhouse;

(g) spaces containing the emergency power supply source other than battery lockers;

(h) points at which extinguishers and fire extinguishing equipment controls are located; and

(i) areas in which passengers, shipboard personnel and crew muster in the event of danger.

## CHAPTER V

## SPECIAL PROVISIONS APPLICABLE TO TANKERS

**70. General rules. –** (1) These rules apply to vessels which are intended to carry the following liquid cargoes having flash point above 60° Celsius;

(a) Non-petroleum, non-hazardous liquid cargoes having flash point of above 60 degrees Celsius;

(b) Petroleum products having flash point of above 60 degrees Celsius;

(c) Vegetable oils of the following types—

(i) Castor oil;

(ii) Coconut oil;

(iii) Corn oil;

(iv) Cotton seed oil;

(v) Groundnut oil;

(vi) Illipe oil;

(vii) Linseed oil;

(viii) Mango kernel oil;

(ix) Palm kernel oil;

(x) Palm kernel olein;

(xi) Palm mid fraction;

(xii) Palm oil;

(xiii) Palmolein;

(xiv) Palm stearin;

(xv) Rapeseed oil;

(xvi) Rice bran oil;

(xvii) Safflower oil;

(xviii) Soyabean oil;

(xix) Sunflower seed oil;

(xx) Tallow; and

(xxi) Tung oil.

(2) Tankers carrying liquid cargoes with a flashpoint below 60° shall be specially considered by the designated authority and such vessels shall as a minimum meet the requirements **prescribed under** the Rules and Regulations for the Design and Construction of Steel Inland Vessels given at Annex-1 of this Rule or of a classification society.

**71. Configuration of cargo tanks, longitudinal bulkheads.-** (1) Where the cargo tank breadth exceeds 0.7B, cargo tanks are normally to be provided with Centre longitudinal bulkheads and where the tank breadth is greater than the 0.7B and Centre longitudinal bulkheads are not fitted, proof of sufficient stability need to be documented**.**

(2) Tankers carrying petroleum oils and vegetable oils are to be provided with a double bottom having height a minimum height of 500 mm.

(3) For tankers carrying petroleum oils and vegetable oils, wing tanks of minimum width 600 mm shall be provided on the sides of the cargo area and wing tanks or spaces shall extend either for the full depth of the vessel's side or from the top of the double bottom to the uppermost deck, disregarding a rounded gunwale where fitted.

(4) Cargo tanks are to be fitted with a visual and audible high-level alarm which indicates when the liquid level in the cargo tank approaches the normal full condition.

(5) The alarm is to be capable of being tested prior to loading.

**72. Hull Scantlings, strength.-** Hull scantlings and strength of tankers shall comply with the requirements prescribed under **the Rules and Regulations for the Design and Construction of Steel Inland Vessels given at Annex-1 of this Rule,** for the intended service of the vessel.

**73. Thermal stresses.-** (1) When liquids carried in tanks require heating and the temperature is more than 90°C, calculations of thermal stresses are required.

(2) The calculations are to give the resultant stresses in the hull structure based on a water temperature of 5°C and an airtemperature of 10°C

**74. Access and Ventilation.-** All cargo zone areas are well ventilated and accessible for surveys and maintenance.

**75. Damage Stability.-** (1) For vessels with independent cargo tanks and for double hull constructions with cargo tanks integrated in the frames of the vessel, the following assumptions are to be taken into consideration for the damaged condition:

(a) extent of side damage as given in the table below:

**TABLE**

| | |
|---|---|
| Longitudinal extent: | At least 0.10 LOA, but not less than 5 [m] |
| Transverse extent: | 0.59 [m] inboard from the vessel's side at right angles to the centerline at the level corresponding to the maximum draught, or when applicable, the distance allowed by 5.4.3.1.2, reduced by 0.01[m] |
| Vertical extent: | From the base line upwards without limit |

(b) extent of bottom damage as given in the table below:

**TABLE**

| | |
|---|---|
| Longitudinal extent: | At least 0.10 LOA, but not less than 5 [m] |

| | |
|---|---|
| Transverse extent: | 3 [m] |
| Vertical extent: | From the base 0.49[m] upwards,<br>the sump excepted |

(c) any bulkhead within the damaged area is to be assumed damaged, which means that the location of bulkheads is to be chosen to ensure that the vessel remains afloat after the flooding of two or more adjacent compartments in the longitudinal direction.

(2) The following shall be applicable:

(a) for bottom damage, adjacent athwartship compartments are also to be assumed flooded;

(b) the lower edge of any non-watertight opening (e.g. windows, doors and access hatchways), at the final stage offlooding, is to be not less than 0.10 [m] above the damage waterline;

(c) permeability is to be assumed to be 95 percent. Where an average permeability of less than 95 percent is calculated for anycompartment, this calculated value obtained may be used;

(d) however, minimum values of permeability, $\mu$, given in the following Table are to be used; and

(e) For the main engine room, only the one-compartment standard need be taken into account, i.e. the end bulkheads of the engine room are to be assumed as not damaged.

**TABLE**

| | |
|---|---|
| Engine Room | 85% |
| Accommodation | 95% |
| Double Bottom, Oil Fuel Tanks, Ballast Tanks etc. depending on whether according to their function theyhave to be assumed as full or empty for vessel floating<br>at the maximum permissible draft | 0% or 95% |

(3) For the intermediate stage of flooding the following criteria have to be fulfilled—

(a) $GZ \geq 0.03$[m]

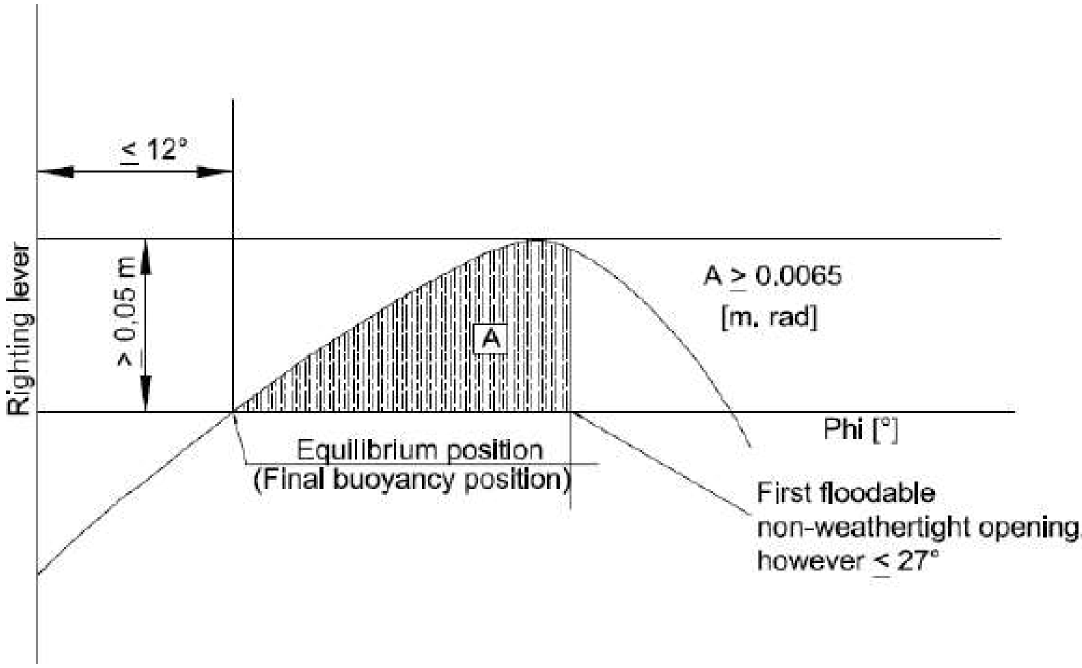
(b) range of positive GZ: 5˚

(4) At the stage of equilibrium (in the final stage of flooding), the angle of heel is not to exceed 12° and non-watertight openings are not to be flooded before reaching the stage of equilibrium; and if such openings are immersed before the stage of equilibrium, the corresponding spaces are to be considered flooded for the purpose of stability calculation.

(5) The positive range of the righting lever curve beyond the stage of equilibrium as per below graph is to have a righting lever of ≥ 0.05[m] in association with an area under the curve of ≥ 0.0065 [m.rad] and the minimum values of stability are to be satisfied up to immersion of the first non-weathertight openings and in any event up to an angle of heel ≤ 27°.

*Explanation:*

If non-weathertight openings are immersed before that stage, the corresponding spaces are to be considered flooded for thepurpose of stability calculation.




(6) If openings through which undamaged compartments may additionally become flooded are capable of being closed watertight, the closing appliances are to be marked accordingly.

(7) Where cross- or down-flooding openings are provided for reduction of unsymmetrical flooding, the time of equalization is not to exceed 15 minutes, provided during the intermediate stages of flooding sufficient stability has been proved.

**76. Cargo pump rooms.-** (1) Separate pump rooms are not required for cargo pumps.

(2) They shall have direct access from open deck and be adequately ventilated to prevent accumulation of oil vapour.

**77. Piping systems for bilge, ballast, oil fuel etc.-** (1) Cofferdams and void spaces located within the cargo area and not intended to be filled with water ballast are to be fitted with suitable means of drainage.

(2) Ballast piping is not to pass through cargo tanks as far as possible and is not to be connected to cargo oil piping and facilities may, however, be made for emergency discharge of water ballast by means of a portable spool connection to a cargo oil pump and where this is arranged, a non-return valve is to be fitted in the ballast suction to the cargo oil pump.

(3) For the purpose of sub-rule (2), the portable spool piece is to be mounted in a conspicuous position in the pump roomand a permanent notice restricting its use is to be prominently displayed adjacent to it and the shut-off valves shall be provided to shut-off the cargo and ballast lines before the spool piece is removed.

**78. Separation of fuel oil and cargo systems.-** (1) The system of storage, transfer, combustion and air pipes for fuel oil for vessel's use shall be entirely separate from systemof loading, un-loading and air pipes for cargo oil.

(2) Cargo pumping and piping systems shall comply with the requirements **prescribed under** the Rules and Regulations for the Design and Construction of Steel Inland Vessels given at Annex-1 of this Rule

**79. Special Requirements for vessels carrying vegetable oil.-** (1) Vessels carrying vegetable oils are to comply with the requirements prescribed under **the Rules and Regulations for the Design and Construction of Steel Inland Vessels given at Annex-1 of this Rule** for this vessel type.

(2) The entire cargo length shall be protected by ballast tanks or spaces other than that for carrying oil as follows—

(a)wing tanks or spaces shall be arranged such that cargo tanks are located inboard of the moulded line of the side shell plating nowhere less than 600 mm; and

(b) double bottom tanks or spaces shall be arranged such that the distance between the bottom of the cargo tanks and the moulded line of the bottom shell plating is not less than 500 mm.

## CHAPTER VI

## SPECIAL PROVISIONS APPLICABLE TO VESSELS CARRYING DANGEROUS GOODS

**80. Special provisions for vessels carrying dangerous goods. -** Inland vessels carrying dangerous goods shall, comply with the requirements **prescribed under** the Rules and Regulations for the Design and Construction of Steel Inland Vessels given at Annex-1 of this Rule, as applicable to such vessels.

## CHAPTER VII

## SPECIAL PROVISIONS APPLICABLE TO CRAFT INTENDED TO FORM PART OF APUSHED OR TOWED CONVOY OR OF A SIDE-BY-SIDE FORMATION

**81. Pushed Convoys.-** (1) Craft intended to be propelled in convoys shall be equipped with coupling devices, bollards or equivalent deviceswhich, as a result of their number and arrangement, ensure a safe connection toother craft in the convoy:

Provided that it shall not apply to crafts solely giving pushing assistance to crafts for berthing.

(2) Category 'A' vessels, which are engaged in towing or pushing operations shall, in addition to these rules, shall comply with the detailed rule requirements **prescribed under** the Rules and Regulations for the Design and Construction of Steel Inland Vessels given at Annex-1 of this Rule for these types of vessels.

**82. Craft suitable for pushing.-** (1) Craft which are to be used for pushing purposes shall incorporate a suitable pushing device and they shall be designedand equipped in such a way as to prevent relative movement between the crafts themselves.

(2) If the craft are joined together with cables the pusher craft shall be equipped with at least two special winches or equivalent coupling devices for tensioning the cables.

(3) The coupling devices shall enable a rigid assembly to be formed with the pushed craft.

(4) Where convoys consist of a pusher craft and a single pushed craft the coupling devices may permit controlled articulation and the necessary drive unitsshall easily absorb the forces to be transmitted and shall be capable of being controlled easily and safely.

(5) The collision bulkhead referred to in clause (a) of sub-rule (1) of Rule 10 shall be dispensed with for vessels being used dedicatedly as pusher crafts.

**83. Craft suitable for being pushed.-** (1) If steering systems, accommodation, engine or boiler rooms are present the relevant requirements of these rules shall apply to them.

(2) The pushed craft shall comply with the collision bulkhead requirements of clause (a) of sub-rule (1) of Rule 10;

(3) Craft intended for being pushed shall be fitted with coupling devices ensuring a safe connection to other craft.

**84. Craft suitable for operating in towed** convoys. - Craft intended for towing shall meet the following requirements:—

(1) The towing devices shall be arranged in such a way that their use does not compromise the safety of the craft, crew orcargo.

(2) Tugging and towing craft shall be fitted with a tow hook which shall be capable of being released safely from the wheelhouse; this shall not apply if the design or other fittings prevent capsizing.

(3) Towing devices shall consist of winches or a tow hook.

(4) The towing devices shall be located ahead of the propeller plane.

(5) This requirement shall not apply to craft that are steered by their propulsion units such as rudder propellers or cycloidal propellers.

(6) For craft solely giving towing assistance to motorised craft for berthing, a towing device such as a bollard or an equivalent device shall suffice.

(7) Where the towing cables could snag on the stern of the vessel, deflector hoops with cable catchers shall be provided.

**85. Craft suitable for propelling side-by-side formations. -** The requirements for crafts propelled in a side-by-side formation shall be specially considered by the vessel on case-to-case basis.

**86. Navigation tests on convoys. -** (1) Navigability and manoeuvrability shall be checked by means of navigation tests and in order to authorise a pusher ormotor vessel to propel a rigid convoy, and to enter this on the Certificate of Survey, the designated authority shall decide which formations are to be presented and shall conduct navigation tests with the convoy in the formations applied for, which the designated authority body regards to be the least favourable ones.

(2) For the purposes of sub-rule (1), the designated authority shall check that the rigid connection of all craft in the convoy is maintained during the manoeuvres.

## CHAPTER VIII

## SPECIAL PROVISIONS APPLICABLE TO VESSELS CARRYING DECK CARGOES

**87. Stability.-** (1) Stability documents shall provide the master with comprehensible information on:

(a) vessel stability for each loading condition. Stability documents shall additionally include a template for calculation of the vessels Longitudinal Centre of Gravity and KG based on the weights and configuration of cargo loaded on deck.

(b) permissible heights for the Centre of gravity of the deck cargo, at which all stability requirements for the craft are satisfied.

(2) The master is to be additionally provided with details regarding the securing arrangements for cargoes, commensurate for the area of operation of the vessel and the strength of such securing arrangements shall be in accordance with the requirements of the designated authority or any classification society.

## CHAPTER IX

## SPECIAL PROVISIONS APPLICABLE TO HIGH-SPEED VESSELS

**88. Construction of High Speed Vessels. –** (1) High-speed vessels shall not be constructed with sleeping accommodation for passengers.

(2) High-speed vessels shall be constructed and maintained under the supervision and in accordance with the applicable rules of the classification society which has special rules for high-speed vessels and as applicable to inland vessels.

**89. Seats and safety belts. -** Seats shall be available for the maximum number of passengers permitted on board and seats shall be fitted with safetybelts.

**90. Freeboard. -** Freeboard of high-speed vessels shall be at least 500 mm.

**91. Buoyancy, stability and subdivision. -** For high-speed vessels, sufficient proof shall be provided, by calculations or trials, for:-

(1) buoyancy and stability characteristics adequate for safety where the craft is operated in the displacement mode, both when intact and when damaged. The intact and damage stability criteria shall be as applicable to a conventional vessel asper the rules;

(2) stability characteristics and stabilising systems adequate for safety where the craft is operated in the dynamic buoyancyphase and the transition phase; and

(3) stability characteristics adequate for safety where the craft is operated in the dynamic buoyancy phase and the transitional phase, and allow to transfer the craft safely to displacement mode in case of any system malfunction.

**92. Wheelhouse. -** (1) The area of obstructed vision for the helmsman in a seated position ahead of the vessel shall not exceed two vessel lengths, irrespective of the loading conditions.

(2) The sum of the blind sector arcs from dead ahead to 22.5° abaft the beam, on either side, shall not exceed 20° and each individual blind sector shall not exceed 5°. The sector of visibility between two blind sectors shall not be less than 10°.

**93. Windows. -** Reflections shall be avoided and a means for avoiding dazzle by sunlight shall be provided.

**94. Surface materials. -** The use of reflective surface materials in the wheelhouse shall be avoided.

**95. Enclosed areas. -** (1) Public rooms and accommodation and the equipment they contain shall be designed so that any person making properuse of those facilities shall not suffer injury during a normal and emergency start or stop, or during manoeuvring in normalcruise and in failure or malfunction conditions.

(2) For the purpose of informing passengers of safety measures, all passenger vessels shall be fitted with optic and acoustic installations visible and audible to everyone on board.

(3) The installations described under sub rule (2) above shall enable the master to give instructions to passengers.

(4) Every passenger shall have access to instructions for emergency situations close to their seat, including a plan of the vessel showing all exits, escape routes, emergency equipment, life-saving equipment and instructions for the use of life jackets.

**96. Exits and escape routes. -** (1) Exits and escape routes shall satisfy the following requirements:-

(a) there shall be easy, safe and quick access from the steering position to rooms and accommodation

accessible tothe public.

(b) escape routes leading to emergency exits shall be clearly and permanently marked.

(c) all exits shall be properly marked. The operation of the opening mechanism shall be obvious from the outside andthe inside.

(d) the escape routes and emergency exits shall have a suitable safety guidance system.

(e) sufficient space for a member of the crew shall be left next to exits.

## CHAPTER X

## SPECIAL PROVISIONS APPLICABLE TO ROLL-ON ROLL-OFF VESSELS

**97. Requirement of Roll On-Roll Off Vessels. -** (1) The requirements of this rule shall apply to mechanically propelled inland vessels which are equipped to ferrypassengers and vehicles on open decks.

(2) Vessels which carry vehicles in spaces other than open decks shall be specially considered by the Designated authorityon a case-by-case basis

(3) These requirements only address the transportation of vehicles with fuel in their tanks for their own propulsion, and do not cover the carriage of vehicles fitted with cargo tanks for the transportation of flammable liquids or dangerous goods.

(4) In addition to the requirements in this rule, all Crafts are to comply with the relevant requirements of the classification society's Rules.

*Explanation*: For the purpose of this rule, 'vehicle' means an automobile powered by internal combustion engines burning petrol or diesel and the carriage of vehicles powered by electric cells, hydrogen or natural gas shall be specially considered.

**98. Documentation. -** The vessel is to carry sufficient documentation onboard to guide the master regarding**: -**

(1) Maximum vehicle loading and number of passengers that the vessel can carry.

(2) Stowage and securing arrangements for vehicles on deck.

(3) Accommodation areas and other areas considered safe for passenger access during voyage.

(4) Safety instructions and fire safety or evacuation or life-saving and other emergency plans.

(5) Operational instructions for vehicle doors and ramps.

(6) Arrangement of fire detectors and call points unless shown on other drawings.

**99. Accommodation arrangements for passengers. -** Crafts carrying passengers are to be provided with seating or sleeping accommodation, in accordance with Inland Waterways (Crew and Passenger Accommodation) Rules 2022.

**100. General safety requirements for crafts equipped for the carriage of vehicles. -** (1) Vehicle decks shall be structurally separated from the Control stations, passenger accommodation or seating spaces and evacuation routes as effectively as practical and if the adjacent arrangement of these spaces is permitted, provision shall be made for easy evacuation of the passenger accommodation away from the vehicle stowage area.

(2) Ramps used for embarkation or disembarkation of passengers to be fitted with suitable portable handrails.

(3) No Smoking signs shall be posted at all entries to vehicle stowage area.

(4) No Smoking signs are to be prominentlydisplayed in the vehicle space.

(5) Any equipment which may constitute a source of ignition of flammable vapours shall not be permitted to be stowed close to the vehicle stowage area

(6) Scuppers from vehicle decks shall not be led to machinery or other spaces where sources of ignition may be present.

**101. Wheel loadings and car deck structure. -** Decks intended to carry vehicles have sufficient strength to withstand the loads that they will be subjected to, in the worstanticipated operating conditions of the craft.

**102. Stability**. - In the calculation of stability, it is to be demonstrated that the vessel has adequate intact stability in the worst anticipatedenvironmental conditions, considering all anticipated stowage arrangement of vehicles.

**103. Drainage. -** Vehicle stowage spaces above bulkhead deck to be fitted with adequate freeing arrangements (scuppers in addition to freeing ports, in areas where the stowage of vehicles may form a temporary well) that shall ensure that the water is rapidlydischarged directly overboard.

**104. Fire Safety and access to open vehicle decks and escape. -** (1) In open vehicle decks to which any passengers carried can have access, the number and locations of the means of escape both below and above the bulkhead deck shall provide safe access to the embarkation deck and the parking arrangements for the vehicles shall maintain the escape routes clear at all times.

(2) One of the escape routes from the machinery spaces where the crew is normally employed shall avoid direct access to the vehicle stowage area.

**105. Structural fire protection. -** (1) Boundaries between vehicle stowage areas and control stations or machinery spaces shall be of **Class A-60** fireintegrity.

(2) Boundaries between vehicle spaces and spaces meant for accommodation, escape, stores, and other cargo spaces shall be insulated to **Class A-30** fire integrity.

**106. Firefighting. -** (1) For all vessels with vehicle spaces, fire monitors (water cannons) effectively covering the full area of the weather deck where vehicles are stowed, are to be fitted and these devices may be either manually or remotely operated.

(2) Arrangements shall be made to ensure immediate availability of a supply of water from the fire main at the required pressure either by permanent pressurization or by suitably placed remote arrangements for the fire pumps.

(3) Adequate freeing arrangements, including scuppers where necessary, shall be fitted so as to ensure that such water is rapidly discharged directly overboard.

(4) The number of nozzles, their size and water pressures shall be in accordance with the **prescribed under** the Rules and Regulations for the Design and Construction of Steel Inland Vessels given at Annex-1 of this Rule.

**107. Portable fire extinguishers. -** An adequate number of portable fire extinguishers shall be carried onboard commensurate with the size of the vessel andthe size of the vehicle stowage area.

**108. Certification. -** Upon compliance with these Rules, the designated authority shall issue the certificate of survey under the Act (Form 5 & 6 of the Inland Vessels Survey and Certification Rules, 2022).

[F. No. IWT-11011/91/2021-IWT]

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**Annex 1**

**Requirements for inspection and testing of materials**

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## Chapter 1

## General Requirements

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| *1* | *Conditions for Manufacture, Survey and Certification* |
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## Section 1

## Conditions for Manufacture, Survey and Certification

### 1.1 Scope

1.1.1 Materials, used for the construction or repair of the hull and machinery are to be manufactured, tested and inspected in accordance with the requirements of this annex.

1.1.2 Materials complying with recognized national or international standards with specifications equivalent to the requirements of this annex may be accepted.

### 1.2 Information to be supplied to the manufacturer

1.2.1 The ship or machinery builder is to provide the manufacturer with such information as is necessary to ensure that inspection and testing can be carried out in accordance with these requirements.

### 1.3 Manufacture

1.3.1 Materials used for the construction or repair of the hull and machinery of ships are to be made at works which have been approved by Designated Authority/Classification Society the type of the product being supplied.

1.3.3 The manufacturer should demonstrate to the satisfaction of Designated Authority/Classification Society the necessary manufacturing and testing facilities are available and are supervised by qualified personnel.

1.3.4 Approval of manufacturers with respect to the materials and grades covered by this annex will be considered by Designated Authority/Classification Society the basis of a detailed description of the manufacturing process and inspection routines, results from testing of materials and a report made by Surveyors confirming the information given by the works and results.

1.3.5 Where the manufacturer has more than one works, approval for individual works would be required.

### 1.4 Survey procedure

1.4.1 The Surveyors are to be allowed access to all the relevant parts of the works and are to be provided with necessary facilities and information to enable them to verify that manufacture is being carried out in accordance with the approved procedure. Adequate facilities are also to be provided for the selection of test materials, the witnessing of mechanical tests and the examination of materials, as required by these Requirements.

1.4.2 Prior to the submission of material for acceptance, manufacturers are to provide the Surveyors with details of the order specification and any special conditions additional to the requirements.

1.4.3 Before final acceptance, all materials are to be submitted to specified tests and examinations under conditions acceptable to the Surveyors. The results are to comply with the requirements and all materials are to be to the satisfaction of the Surveyors.

1.4.4 The specified tests and examinations are to be carried out prior to the dispatch of all finished materials from the manufacturer's works. Where materials are supplied in the rough or unfinished condition, as many as possible of the specified tests are to be carried out by the manufacturer and any tests or examinations not completed are to be carried out in consultation with the Surveyors, at a subsequent stage of manufacture.

1.4.5 In the event of any material proving unsatisfactory, during subsequent working, machining or fabrication, it is to be rejected, not withstanding any previous certification.

### 1.5 Chemical composition

1.5.1 The chemical composition of the ladle samples is to be determined by the manufacturer in an adequately equipped and competently staffed laboratory. The manufacturer's analysis will be accepted, but may be subject to occasional independent checks if required by the Surveyors.

1.5.2 At the discretion of the Surveyors, a check chemical analysis of suitable samples from products may also be required. These samples are to be taken from the material used for mechanical tests, but where this is not practicable an alternative procedure for obtaining a representative sample is to be agreed with the manufacturer.

### 1.6 Heat treatment

1.6.1 Materials are to be supplied in the condition specified in, or permitted by the requirements. Heat treatment is to be carried out in properly constructed furnaces which are efficiently maintained and have adequate means for control and recording of temperature. The furnace dimensions are to be such as to allow the whole item to be uniformly heated to the necessary temperature. In the case of very large components which require heat treatment, alternative methods will be specially considered.

### 1.7 Test material

1.7.1 Sufficient test material is to be provided for the preparation of the tests detailed in the specific requirements. It is, however, in the interests of manufacturers to provide additional material for any

retests which may be necessary, as insufficient or unacceptable test material may be a cause for rejection.

1.7.2 The test material is to be representative of the item or batch and is not to be separated until all the specified heat treatment has been completed, except where provision for an alternative procedure is made in the subsequent chapters of this Annex.

In case of castings where separately cast test samples are accepted, the test samples are to be cooled down under the same conditions as the castings.

1.7.3 All test material is to be selected by the surveyor and identified by suitable markings which are to be maintained during the preparation of the test specimen.

**1.8 Mechanical tests**

1.8.1 The number and direction of test specimens and their dimensions are to be in accordance with the requirements of subsequent chapters of this Annex and the specific requirements for the product.

1.8.2 Where Charpy impact tests are required, a set of three test specimens are to be prepared and the average energy value is to comply with the requirements of subsequent Chapters of this annex. One individual value may be less than the required average value provided that it is not less than 70 per cent of that value.

1.8.3 Where metric or imperial units are to be used for acceptance testing, the specified values are to be converted in accordance with the appropriate conversions given in Table 1.8.1.

**Table 1.8.1 : Conversion of SI units to metric and imperial units**

| | |
|---|---|
| 1 N/mm$^2$ or Mpa | = 0.102 kgf/mm$^2$ |
| 1 N/mm$^2$ or Mpa | = 0.0647 tonf/in$^2$ |
| 1 N/mm$^2$ or Mpa | = 0.145 x 10$^3$ lbf/in$^2$ |
| 1 J | = 0.102 Kgf m |
| 1 J | = 0.738 ft Ibs |
| 1 Kgf/mm$^2$ | = 9.81 N/mm$^2$ or MPa |
| 1 tonf/in$^2$ | = 15.45 N/mm$^2$ or MPa |
| 1 Ibf/in$^2$ | = 6.89 x 10$^{-3}$ MPa |
| 1 kgf m | = 9.81 J |
| 1 ft lbf | = 1.36 J |

Notes :

The conversions may be rounded to the nearest multiples as follows :

| | | |
|---|---|---|
| 1 | For tensile strength values at ambient temperature | 1 Kgf/mm$^2$ |
| | | 0.5 tonf/in$^2$ |
| | | 1 x 10$^3$ lbf.in$^2$ |
| | | 10N/mm$^2$ |
| 2 | For yield and proof stress values at ambient temperature | 0.5 kgf/mm$^2$ |
| | | 0.2 tonf/in$^2$ |
| | | 0.5 x 10$^3$ lbf/in$^2$ |
| | | 5 N/mm$^2$ |

| | | |
|---|---|---|
| 3 | For lower yield or proof stress values at elevated temperatures and stress to rupture. | 0.1 kgf/mm$^2$<br>0.05 tonf/in$^2$<br>0.1 x $10^3$ lbf/in$^2$<br>1 N/mm$^2$ |
| 4 | For impact energy values | 0.1 kgf m<br>1 ft lbf<br>1 J |

**1.9 Definitions**

1.9.1 The following definitions are applicable to this Part:

Item A single forging, casting, plate, tube or other rolled product as delivered.

Piece The rolled product from a single slab or billet or from a single ingot if this is rolled directly into plates, strips, sections or bars.

Batch A number of similar items or pieces presented as a group for acceptance testing.

**1.10 Retest procedures**

1.10.1 Where the result of any test, other than an impact test, does not comply with the requirements, two additional tests of the same type may be taken. For acceptance of the material satisfactory results are to be obtained from both of these tests.

1.10.2 Where the results from a set of three impact test specimens do not comply with the requirements, an additional set of three impact test specimens may be tested provided that not more than two individual values are less than the required average value and, of these, not more than one is less than 70 per cent of this average value. The results obtained are to be combined with the original results to form a new average which, for acceptance, is not to be less than the required average value. Additionally, for these combined results, not more than two individual values are to be less than the required average value and, of these, not more than one is to be less than 70 per cent of this average value.

1.10.3 The additional tests detailed in 1.10.1 and 1.10.2 are, where possible, to be taken from material adjacent to the original tests. For castings, however, where insufficient material remains in the original test samples, the additional tests may be prepared from other test samples representative of the castings.

1.10.4 When unsatisfactory results are obtained from tests representative of a batch of material, the item or piece from which the tests were taken is to be rejected. The remainder of the batch may be accepted provided that two further items or pieces are selected and tested with satisfactory results. If the tests from one or both of these additional items or pieces give unsatisfactory results, the batch is to be rejected.

1.10.5 When a batch is rejected, the remaining items or pieces in the batch may be re-submitted individually for test, and those which give satisfactory results may be considered for acceptance by the Surveyors.

1.10.6 At the option of the manufacturer, rejected material may be re-submitted as another grade and may then be considered for acceptance by the Surveyors, provided that the test results comply with the appropriate requirements.

1.10.7 When material which is intended to be supplied in the "as rolled" or "hot finished" condition fails test, it may be suitably heat treated and re-submitted for test, with the prior concurrence of the ship or machinery builder. Similarly materials supplied in the heat-treated condition may be re-heat treated and re-submitted for test.

**1.11 Visual and non-destructive examination**

1.11.1 Prior to the final acceptance of materials, surface inspection, verification of dimensions and non-destructive examination are to be carried out in accordance with the requirements detailed in subsequent chapters of this annex.

1.11.2 When there is visible evidence to doubt the soundness of any material or component, such as flaws in test specimens or suspicious surface marks, the manufacturer is expected to prove the quality of the material by any acceptable method.

**1.12 Rectification of defective material**

1.12.1 Small surface imperfections may be removed by mechanical means provided that, after such treatment, the dimensions are acceptable, the area is proved free from defects and the rectification has been completed in accordance with applicable requirements of subsequent chapters of this annex and to the satisfaction of Surveyors.

1.12.2 The repair of defects by welding can be accepted only when permitted by the appropriate specific requirements and provided that the agreement of the Surveyor is obtained before the work is commenced. When a repair has been agreed, it is necessary in all cases to prove by suitable methods of non-destructive examination that the defects have been completely removed before welding is commenced. Welding procedures and

inspection on completion of the repair are to be in accordance with the appropriate specific requirement and are to be to the satisfaction of the Surveyor.

**1.13 Identification of materials**

1.13.1 The manufacturer is to adopt a system of identification which will enable all finished material to be traced to the original cast, and the Surveyors are to be given all facilities for so tracing the material when required. When any item has been identified by the personal mark of a Surveyor, or his deputy, this is not to be removed until an acceptable new identification mark has been made. Failure to comply with this condition will render the item liable to rejection.

1.13.2 Before any item is finally accepted it is to be clearly marked by the manufacturer in at least one place with the particulars detailed in the appropriate specific requirements.

1.13.3 Hard stamping is to be used except where this may be detrimental to the material, in which case stenciling, painting or electric etching is to be used. Paints used to identify alloy steels are to be free from lead, copper, zinc or tin, i.e., the dried film is not to contain any of these elements in quantities more than 250 ppm.

1.13.4 Where a number of identical items are securely fastened together in bundles, the manufacturer need only brand the top of each bundle. Alternatively a durable label giving the required particulars may be attached to each bundle.

## Chapter 2

## Mechanical Testing Procedures

***Contents***



### Section 1

### General Requirements

**1.1 General**

1.1.1 All tests are to be carried out by competent personnel. The machines are to be maintained in satisfactory and accurate condition and are to be recalibrated at approximately annual intervals. This calibration is to be carried out by a nationally recognized Authority or other organization of standing and is to be carried out to the satisfaction of Surveyors. The accuracy of test machines is to be within ± one per cent. A record of all calibrations is to be kept available in the test house.

Testing machines are to be calibrated in accordance with the following or other equivalent recognized standards:

a) Tensile / compression testing : ISO 7500-1

b) Impact testing : ISO 148-2

**1.2 Selection of test samples**

1.2.1 Test samples are to be selected by the Surveyor unless otherwise agreed.

1.2.2 All materials in a batch presented for testing are to be of the same product form (e.g. plates, sections, bars). Normally, the materials are to be from the same cast and in the same condition of heat treatment.

**1.3 Preparation of test specimens**

1.3.1 If test samples are cut from material by flame cutting or shearing, a reasonable margin is required to enable sufficient material to be removed from the cut edges during final machining.

1.3.2 Test specimens are to be cut and prepared in a manner which does not affect their properties, i.e. not subjected to any significant cold straining or heating.

1.3.3 Where possible, test specimens from rolled materials are to retain their rolled surface on both sides.

**1.4 Discarding of test specimens**

1.4.1 If a test specimen fails because of faulty manufacture, visible defects, or incorrect operation of the testing machine, it may be discarded at the Surveyor's discretion and replaced by a new test specimen prepared from material adjacent to the original test.

## Section 2

## Tensile Testing

**2.1 Dimensions of tensile test specimens**

2.1.1 Generally, proportional test specimens with a gauge length of $5.65\sqrt{S_o}$ (where $S_o$ is the cross-sectional area of the test length) are to be used. Where it is not possible to use such specimens, non-proportional specimens may be considered.

2.1.2 For the purpose of determining the different parameters related to tensile testing, three different types of test specimens may be used :

- Round test specimens;
- Flat test specimens; and
- Full cross-section test specimens.

See also Fig.2.1.1.

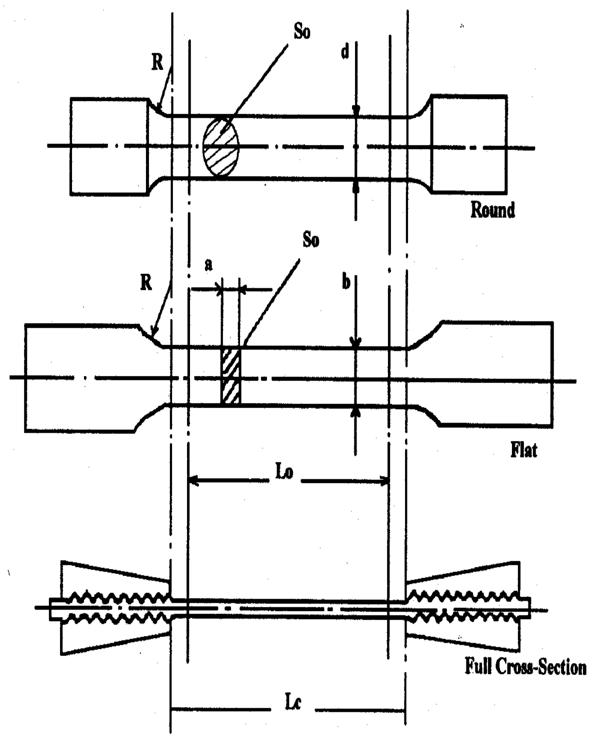



**Fig. 2.1.1 : Tensile test specimens**

2.1.2.1 The following symbols have been used in the figure and in subsequent paragraphs:-

d =diameter

a =thickness of specimen

b =width

Lo = Original gauge length

Lc = Parallel length

So = Original cross-sectional area

R = Transition radius

D =External tube diameter

t = plate thickness

2.1.2.2 The gauge length may be rounded off to the nearest 5 [mm] provided that the difference between this length and Lo is less than 10% of Lo.

2.1.2.3 For plates with thickness equal to and greater than 3 [mm], test specimen according to alternatives A or B given below are to be used. Where the

capacity of the available testing machine is insufficient to allow the use of a test specimen of full thickness, this may be reduced by machining one of the rolled surfaces.

Alternatively for materials over 40 [mm] thick, proportional round test specimens with dimensions as specified in C below may be used.

Alternative A, Non-proportional flat test specimen

a = t

b =25 [mm]

Lo =200 [mm]

Lc ≥ 212.5 [mm]

R =25 [mm]

Alternative B, Proportional flat test specimen

a = t

b =25 [mm]

Lo = 5.65 $\sqrt{S_o}$

Lc ≈Lo + 2 $\sqrt{S_o}$

R =25 [mm]

Alternative C, round test specimen

d =14 [mm] in general, but in no case less than 10 mm nor more than 20 [mm].

Lo = 5d [mm

Lc ≥ Lo + d/2 [mm]

R =10 [mm], in general

≥ 1.5 d [mm], for nodular cast iron and materials with a specified elongation of less than 10%.

2.1.2.4 The round test specimen is to be located with its center t/4 from the plate surface or as close to this position as possible.

2.1.2.5 For sheets and strips with thickness less than 3 [mm]

a = t

b =12.5 [mm]

Lo =50 [mm]

Lc ≈75 [mm]

R =25 [mm]

2.1.2.6 Wires: Full cross sectional test specimen with the following dimensions is to be used:

Lo =200 [mm]

Lc =Lo + 50 [mm].

2.1.2.7 For forgings, castings (excluding grey cast iron) and bars round test specimens with dimensions as specified in alternative C of 2.1.2.3 are usually to be used.

2.1.2.8 If for special reasons, other dimensions are to be used, they will have to conform with the following geometric relationship:

Lo =5d;

Lc =Lo + d:

R=10 [mm], except for materials with a specified minimum elongation A ≤ 10 per cent, where R is to be 1.5 x d.

2.1.2.9 For tubes, test specimen according to alternative A or B below are to be used:

*Alternative A* :- Full cross-section test specimens with plugged ends -

Lo = 5.65 $\sqrt{S_o}$

Lc ≈ Lo + D/2

Lc is the distance between the grips or the plugs, whichever is smaller.

*Alternative B* :- Strip

a =wall thickness of tube

b ≥ 12 [mm]

Lo = 5.65 $\sqrt{S_o}$

Lc = Lo + 2b

The parallel test length is not to be flattened. but the enlarged ends may be flattened for gripping in the testing machine.

Round test specimens may also be used provided that the wall thickness is sufficient to allow the machining of such specimens to the dimensions in alternative C in 2.1.2.3 above with their axes located at the midwall thickness.

2.1.2.10 The above is subject to any specific dimensions or minimum cross-sectional area requirements, with respect to test specimens, given in any subsequent Chapters of this Part.

2.1.2.11 Tensile test specimens for grey cast iron are to be machined to the dimensions shown in Fig.2.1.2. Usually test specimens are machined from separately cast standard test coupons with 30 [mm] diameter.

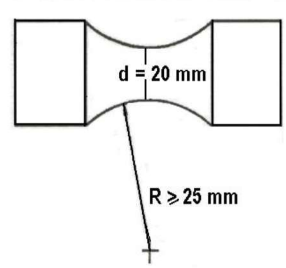



**Fig : 2.1.2 : Tensile test specimen for grey cast iron**

2.1.2.12 The tolerances on specimen dimensions are to be in accordance with ISO 6892-98 or other recognised standards as appropriate.

**2.2 Fracture elongation**

2.2.1 Unless otherwise specified, the elongation values in this part correspond to those required for proportional test specimens over a gauge length 5.65 $\sqrt{S_o}$.

If any part of the fracture takes place outside of the middle one-third of the original gauge length, the elongation value obtained may not be representative of the material. In such cases if the elongation measured is less than the minimum requirements, the test result may be discarded and a retest carried out.

2.2.2 If the material is ferritic steel of low or medium strength and not cold worked the elongation may also be measured on a non- proportional gauge length after agreement with Designated Authority/Classification Society.

In that case the elongation required is to be calculated from the following formula:

$$A_o = 2 \text{ x } A_s \left[ \frac{\sqrt{S_o}}{L_o} \right]^{0.4}$$

*where,*

$A_o$ = Required elongation for the non-proportional test specimen

$A_s$ = Specified elongation on a gauge length of $5.65\sqrt{S_o}$

$S_o$ = Cross-sectional area of test specimen

$L_o$ = Gauge length of test specimen.

**2.3 Definition of yield stress**

2.3.1 The yield phenomenon is not exhibited by all the steels detailed in this Part but, for simplification the term "Yield Stress" is used throughout when requirements are specified for acceptance testing at ambient temperature.

2.3.2 Where reference is made to "Yield Stress" in the requirements for carbon, carbon-manganese and alloy steel products and in the requirements for the approval of welding consumables, either the upper yield stress or the 0.2 per cent proof stress under load is to be determined.

2.3.3 For austenitic and duplex stainless steel products and welding consumables, both the 0.2 per cent and 1.0 per cent proof stresses are to be determined.

**2.4 Procedure for tensile testing at ambient temperature**

2.4.1 Unless otherwise specified, the test is to be carried out at ambient temperature between $10^0$C and $35^0$C.

2.4.2 Yield stress (Yield point) is to be taken as the value of stress measured at the commencement of plastic deformation at yield or the value of the stress measured at the first peak obtained during yielding even when the peak is equal to or less than any subsequent peaks observed during plastic deformation at yield. The tensile test is to be carried out with an elastic stress rate within the limits indicated in Table 2.4.2.

**Table 2.4.2**

| Modulus of elasticity of the material (E) [N/mm$^2$] | Rate of stressing [N/mm$^2$] per second | |
|---|---|---|
| | **Min.** | **Max.** |
| < 150 000 | 2 | 20 |
| ≥ 150 000 | 6 | 60 |

2.4.3 After reaching the yield or proof load, the straining rate may be increased to a maximum of 0.008 per second for the determination of tensile strength.

2.4.4 For steel, the upper yield stress is to be calculated from :

a) the load immediately prior to a distinct drop in the testing machine lever; or

b) the load immediately prior to a fall back in the movement of the pointer or the load at a marked hesitation of this pointer; or

c) a load/extension diagram using the value of load measured either at the commencement of plastic deformation or yield or at the first peak obtained during yielding even when that peak is equal to or less than any subsequent peaks observed.

2.4.5 The 0.2 or 1.0 per cent proof stress (non-proportional elongation) is to be determined from an accurate load/extension diagram by drawing a line parallel to the straight elastic portion and distant from it by an amount representing 0.2 or 1.0 per cent of extensometer gauge length. The point of intersection of this line with the plastic portion of the diagram represents the proof load, from which 0.2 or 1.0 per cent proof stress can be calculated.

**2.5 Procedure for tensile testing at elevated temperatures**

2.5.1 The test specimens used for the determination of lower yield or 0.2 per cent proof stress at elevated

temperatures are to have an extensometer gauge length of not less than 50 [mm] and a cross sectional area of not less than 65 [$mm^2$]. Where, however, this is precluded by the dimensions of the product or by the test equipment available, the test specimen is to be of the largest practical dimensions.

2.5.2 The heating apparatus is to be such that the temperature of the specimen during testing does not deviate from that specified by more than ± 5°C.

2.5.3 The straining rate when approaching the lower yield or proof load is to be controlled within the range 0.1 to 0.3 per cent of the extensometer gauge length per minute.

2.5.4 The time intervals used for estimation of strain rate from measurements of strain are not to exceed 6 seconds.

## Section 3

## Impact Tests

### 3.1 Dimensions of test pieces

3.1.1 Impact tests are to be of either the charpy V-notch or the charpy U-notch type as required by the subsequent Chapters. The test specimens are to be machined to the dimensions and tolerances given in Table 3.1.1 and Table 3.1.2 and are to be carefully checked for dimensional accuracy.

3.1.2 For material under 10 [mm] in thickness the largest possible size of standard subsidiary charpy V-notch is to be prepared with the notch cut in the narrow face. Generally, impact tests are not required when the thickness of material is less than 5 [mm] (less than 6 [mm] for pipes and tubes).

**Table 3.1.1 : Dimensions and tolerances for charpy V-notch impact test specimens**

| Dimensions | Nominal | Tolerance |
|---|---|---|
| Length [mm] | 55 | ± 0.60 |
| Width [mm] | | |
| - standard specimen | 10 | ± 0.11 |
| - subsize specimen | 7.5 | ± 0.11 |
| - subsize specimen | 5 | ± 0.06 |
| Thickness [mm] | 10 | ± 0.06 |
| Angle of notch | 45° | ± 2° |
| Depth below notch [mm] | 8 | ± 0.06 |
| Root radius [mm] | 0.25 | ± 0.025 |
| Distance of notch from end of specimen [mm] | 27.5 | ± 0.42 |
| Angle between plane of symmetry of notch and longitudinal axis of test specimen | 90° | ± 2° |
| Ref. Fig.3.1.1 | | |

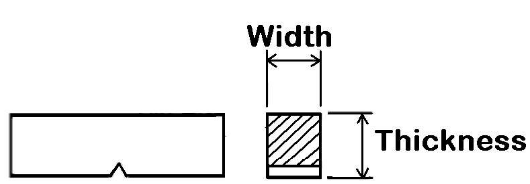



**Fig.3.1.1**

**Table 3.1.2 : Dimensions and tolerances for charpy U-notch impact test specimens**

| Dimensions | Nominal | Tolerance |
|---|---|---|
| Length [mm] | 55 | ± 0.60 |
| Width [mm] | 10 | ± 0.11 |
| Thickness [mm] | 10 | ± 0.11 |
| Depth of notch [mm] | 5 | ± 0.09 |
| Root radius [mm] | 1 | ± 0.07 |
| Distance of notch from end of test specimen [mm] | 27.5 | ± 0.42 |
| Angle between plane of symmetry of notch and longitudinal axis of test specimen | 90° | ± 2° |
| Ref. Fig.3.1.1 | | |

**3.2 Testing procedure**

3.2.1 All impact tests are to be carried out on Charpy machines having a striking energy of not less than 150J and complying with following requirements:-

a) Distance between supports 40 + 5 [mm]
- 0

b) Radius of curvature of supports 1 -1.5 [mm]

c) Taper of supports 1 in 5

d) Angle at tip of hammer 30 ± 1°

e) Radius of curvature of hammer 1.0 -2.5 [mm]

f) Speed of hammer at the instant of striking 4.5 - 7 [m/sec].

3.2.2 Charpy U-notch impact tests are generally to be carried out at ambient temperature. Charpy V- notch impact tests may be carried out at ambient or lower temperatures in accordance with specific requirements given in subsequent Chapters. Where the test temperature is other than ambient, the temperature of the test specimen is to be controlled to within ± 2°C for sufficient time to ensure uniformity throughout the cross section of the test specimen, and suitable precautions are to be taken to prevent any significant change in temperature during the actual test. In cases of dispute, ambient temperature is to be considered as 18°C -27°C.

3.2.3 When reporting results, the units used for expressing the energy absorbed and the testing temperature are to be clearly stated. It is preferred that energy values for both charpy V-notch and charpy U-notch impact tests be expressed in Joules and not [J/cm$^2$].

3.2.4 The minimum average values for specimens are as given in Table 3.2.4.

**Table 3.2.4**

| Charpy V-notch specimen size | Minimum energy, average of 3-specimens |
|---|---|
| 10 mm x 10 mm | E |
| 10 mm x 7.5 mm | 5E/6 |
| 10 mm x 5.0 mm | 2E/3 |

Notes:

E = the values of energy specified for full thickness 10 mm x 10 mm specimens

All other dimensions and tolerances are to be as specified in Table 3.1.1.

Only one individual value may be below the specified average value provided it is not less than 70% of that value.

In all cases, the largest size Charpy specimens possible for the material thickness shall be machined

## Section 4

## Ductility Testing of Pipes and Tubes

### 4.1 Bend tests

4.1.1 The test specimens are to be cut as circumferential strips of full wall thickness and with a width of not less than 40 [mm]. For thick walled pipes, the thickness of the test specimens may be reduced to 20 [mm] by machining. The edges of specimen may be rounded to a radius of 1.6 [mm].

4.1.2 Testing is to be carried out at ambient temperature, and the specimens are to be doubled over, in the direction of the original curvature, around a former. The diameter of the former is to be in accordance with the specific requirements for the material. The test is to be considered satisfactory if, after bending, the specimens are free from cracks and laminations. Small cracks at the edges of the test specimen are to be disregarded.

### 4.2 Flattening tests

4.2.1 The test specimens are to be cut with the ends perpendicular to the axis of the pipe or tube. The length of the specimen is to be not less than 10 [mm] or greater than 100 [mm].

4.2.2 Testing is to be carried out at ambient temperature and is to consist of flattening the specimens in a direction perpendicular to the longitudinal axis of the pipe. (Reference is made to ISO 8492). Flattening is to be carried out between two plain parallel and rigid platens which extend over both the full length and width after flattening of the test specimen. Flattening is to be continued until the distance between the platens, measured under load, is not greater than the value given by the formula:-

$$H = \frac{t(1+C)}{C + \frac{t}{D}}$$

where,

H = distance between platens [mm];

t = specified thickness of the pipe [mm];

D = Specified outside diameter [mm];

C = a constant dependent on the steel type and detailed in the specific requirements.

After flattening, the specimens are to be free from cracks or other flaws. Small cracks at the ends of the test specimens may be disregarded.

4.2.3 For welded pipes or tubes, the weld is to be placed at an angle of 90° to the direction of the pressure.

### 4.3 Drift expanding test

4.3.1 The test specimens are to be cut with the ends perpendicular to the axis of the tube. The edges of the end to be tested may be rounded by filing.

Metallic tubes: The length 'L' equal to twice the external diameter 'D' of the tube if the angle of the drift is 30° and L equal to 1.5D if the angle of the drift is 45° or 60°. (Reference ISO 8493). The test piece may be shorter if after testing the remaining cylindrical portion is not less than 0.5D.

The rate of penetration of the mandrel is not to exceed 50 [mm]/minute.

4.3.2 Testing is to be carried out at ambient temperature and is to consist of expanding the end of the tube symmetrically by means of a hardened conical steel mandrel having a total included angle of 45° or 60°. The mandrel is to be forced into the test specimen until the percentage increase in the outside diameter of the end of the test specimen is not less than the value given in the specific requirements for boiler and superheater tubes. The mandrel is to be lubricated, but there is to be no rotation of the tube or mandrel during the test. The expanded portion of the tube is to be free from cracks or other flaws.

### 4.4 Flanging tests

4.4.1 The test specimens are to be cut with the ends perpendicular to the axis of the tube. The length of the specimens is to be approximately 1.5D. The length may be shorter provided that after testing the remaining cylindrical portion is not less than O.5D (Reference ISO 8494). The edges of the end to be tested may be rounded by filing. The rate of penetration shall not exceed 50 [mm]/minute.

4.4.2 Testing is to be carried out at ambient temperature and is to consist of flanging the end of the tube symmetrically by means of hardened conical steel mandrels.

4.4.3 The first stage of flanging is to be carried out with a conical angled mandrel having an included angle of approximately 90° (See Fig.4.4.3(a)) The completion of the test is achieved with a second forming tool as shown in Fig.4.4.3(b). The mandrels are to be lubricated and there is to be no rotation of the tube or mandrels during the test. The test is to continue until the drifted portion has formed a flange perpendicular to the axis of the test specimens. The percentage increase in the external diameter of the end of specimens is not to be less than the value given in the specific requirements for boiler and superheater tubes. The cylindrical and flanged portion of the tube is to be free from cracks or other flaws.

**4.5 Ring expanding test**

4.5.1 The test piece consists of a ring having a length of between 10 to 16 [mm]. (Reference ISO 8495). The rate of penetration of the mandrel is not to exceed 30 [mm]/second.

**4.6 Ring tensile test**

4.6.1 The ring is to have a length of about 15 [mm] with plain and smoothed ends cut perpendicular to the tube axis. The ring is to be drawn to fracture by means of two mandrels placed inside the ring and pulled in tensile testing machine. The rate shall not exceed 5 [mm]/second. (Reference ISO 8496).

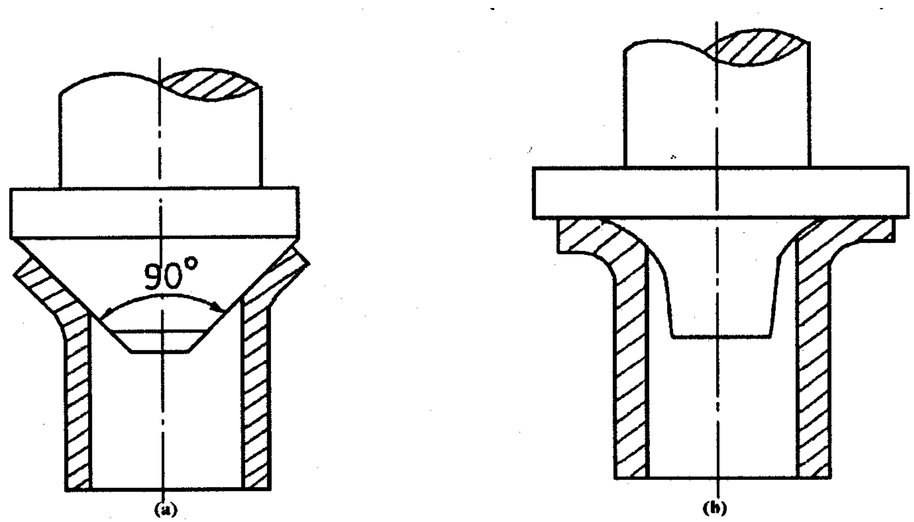



**Fig.4.4.3 : Flanging test**

**Chapter 3**

**Rolled Steel Plates, Strips, Sections and Bars**

**Contents**



**Section 1**

**General Requirements**

**1.1 Scope**

1.1.1 This Chapter gives general requirements for hot rolled plates, wide flats, strips and sections intended for use in the construction of ships, boilers, pressure vessels and machinery structures. These requirements are also applicable to hot rolled bars, except where such materials are intended for the manufacture of bolts, shafts, etc. by machining operations only.

When used for this purpose hot rolled bars are to comply with the requirements of Ch. 5.

**1.2 Manufacture**

1.2.1 The steel is to be manufactured at the approved works by the open hearth, electric furnace or one of the basic oxygen processes or by other processes specially approved by Designated Authority/Classification Society.

1.2.2 The suitability of each grade of steel for forming and welding is to be demonstrated during the initial approval tests at the steel works. The type and the extent of testing required is at the discretion of Designated Authority/Classification Society.

1.2.3 It is the manufacturer's responsibility to assure that effective process and production controls in operation are adhered to in accordance with the manufacturing specifications. Where control imperfection that may lead to inferior quality of product occurs, the manufacturer is to identify the cause and establish counter measure to prevent its occurrence. Also the complete investigation report is to be submitted to the Surveyor. Each affected piece considered for further usage is to be tested to the Surveyor's satisfaction.

The frequency of testing may be increased to gain confidence for subsequent products as considered necessary.

**1.3 Quality of materials**

1.3.1 Defects not prejudicial to the proper application of steel are not, except by special agreement, to be grounds for rejection. Where necessary, suitable methods of non-destructive examination may be used for the detection of harmful surface and internal defects. The extent of this examination, together with appropriate acceptance standards, is to be agreed between the purchaser, manufacturer and Surveyors.

**1.4 Thickness tolerance of plates and wide flats with width ≥ 600 [mm]**

1.4.1 Following requirements are applicable to the tolerance on thickness of steel plates and wide flats with widths of 600 [mm] or greater (herein after referred to as: product or products) with thickness of 5 [mm] and over, covering the following :

(i) Normal and higher strength hull structural steels (Refer Sec 2, and Sec 3)

(ii) High strength steels for welded structure ( Refer Sec 4)

(iii) Steel for machinery structures (Refer Sec 7)

These requirements do not apply to products intended for the construction of boilers, pressure vessels and independent tanks, e.g. for the transportation of liquefied gases or chemicals.

These requirements do not apply to products intended for the construction of lifting appliances.

1.4.2 The tolerance on thickness of a given product are defined as follows:

a) Minus tolerance is the lower limit of the acceptable range below the nominal thickness.

b) Plus tolerance is the upper limit of the acceptable range above the nominal thickness.

Note : Nominal thickness is stated by the purchaser at the time of enquiry and order.

1.4.3 The minus tolerance for products for normal strength, higher strength and high strength quenched and tempered steels is 0.3 [mm] irrespective of nominal thickness.

1.4.4 The minus tolerance for products intended for machinery structures are to be in accordance with Table 1.4.4.

1.4.5 The tolerance for thickness below 5 [mm] is to be in accordance with a national or international standard, e.g. Class B of ISO 7452:2013. However, the minus tolerance is not to exceed 0.3 [mm].

**Table 1.4.4**

| Nominal thickness [mm] | Minus tolerance on nominal thickness [mm] |
|---|---|
| ≥ 3 to < 5 | -0.3 |
| ≥ 5 to < 8 | -0.4 |
| ≥ 8 to < 15 | -0.5 |
| ≥ 15 to < 25 | -0.6 |
| ≥ 25 to < 40 | -0.7 |
| ≥ 40 to < 80 | -0.9 |
| ≥ 80 to < 150 | -1.1 |
| ≥ 150 to < 250 | -1.2 |
| ≥ 250 | -1.3 |

1.4.6 The plus tolerance on nominal thickness is to be in accordance with a recognized national or international standard or as specified.

1.4.7 The tolerance on sections (except for wide flats) are to be in accordance with the requirements of recognized international or national standard.

1.4.8 The tolerances on nominal thickness are not applicable to areas repaired by grinding. For areas repaired by grinding, the requirements of Sec.2, 2.7.4.1 are to be applied, unless stricter requirements as per a recognized standard are specified by the purchaser.

1.4.9 For materials intended for applications as detailed in Sec. 5 and 6, no minus tolerance is permitted in the thickness of plates and strip.

1.4.10 The responsibility for verification and maintenance of the production within the required tolerance rests with the manufacturer. The Surveyor may require to witness some measurements.

1.4.11 The responsibility for storage and maintenance of the delivered products with acceptable level of surface conditions rests with the shipyard before the products are used in fabrication.

1.4.12 Where zero minus tolerance is applied in accordance with Class C of ISO 7452-2013 or equivalent national or international standards, the requirements of 1.4.13 to 1.4.15 need not be applied.

Additionally, if Class C of ISO 7452-2013 is applied, it is required that the steel mill demonstrates to the satisfaction of Designated Authority/Classification Society that the number of measurements and measurement distribution is appropriate to establish that the mother plates produced are at or above the specified nominal thickness.

1.4.13 Average thickness

1.4.13.1 The average thickness of products is defined as the arithmetic mean of the measurements made in accordance with the requirements of 1.4.14.

1.4.13.2 The average thickness of products for hull structural steels is not to be less than the nominal thickness.

1.4.14 Thickness measurements

1.4.14.1 The thickness is to be measured at locations of products as defined in 1.4.15.

1.4.14.2 Automated method or manual method may be applied to the thickness measurements.

1.4.14.3 The procedure and the records of measurements are to be made available to the Surveyor and copies provided on request.

1.4.15 Thickness measuring locations

1.4.15.1 The requirements of 1.4.15.2 are to be applied to the thickness measuring locations for the thickness tolerance and the average thickness of the product.

1.4.15.2 At least two lines among Line 1, Line 2 or Line 3 as shown in Fig.1.4.15.2 are to be selected for the thickness measurements and at least three points on each selected line are to be selected for thickness measurement. If more than three points are taken on each line the number of points are to be equal on each line.

Note : The measurement locations apply to a product rolled directly from one slab or steel ingot even if the product is to be later cut by the manufacturer. Examples of the original measurements relative to later cut products are shown in Fig.1.4.15.2b), It is to be noted that the examples shown are not representative of all possible cutting scenarios.

For automated methods, the measuring points at sides are to be located not less than 10 [mm] but not greater than 300 [mm] from the transverse or longitudinal edges of the product.

For manual methods, the measuring points at sides are to be located not less than 10 [mm] but not greater than 100 [mm] from the transverse or longitudinal edges of the product.

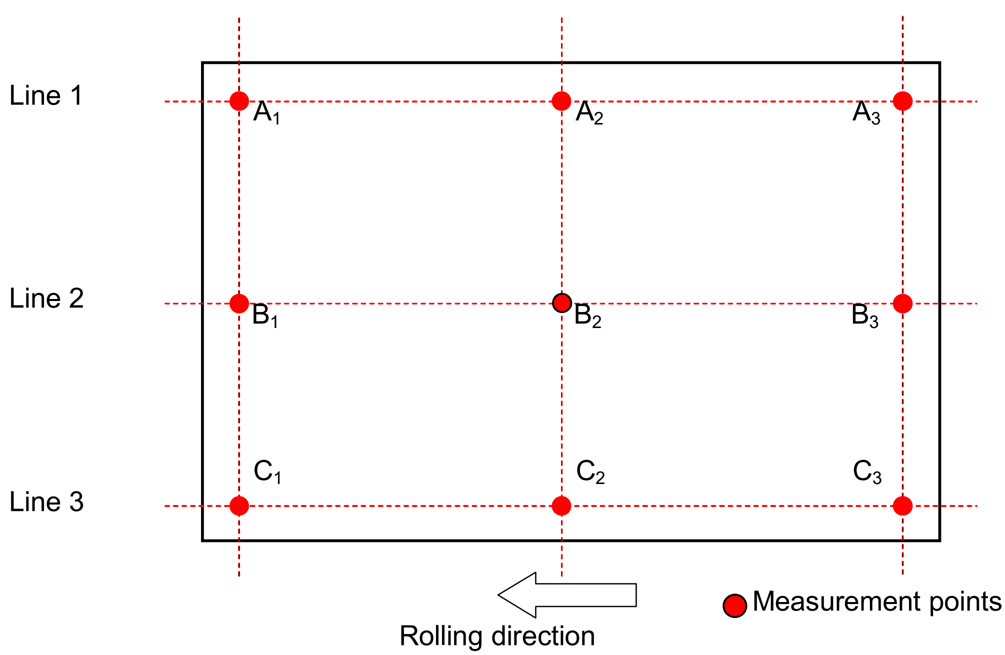
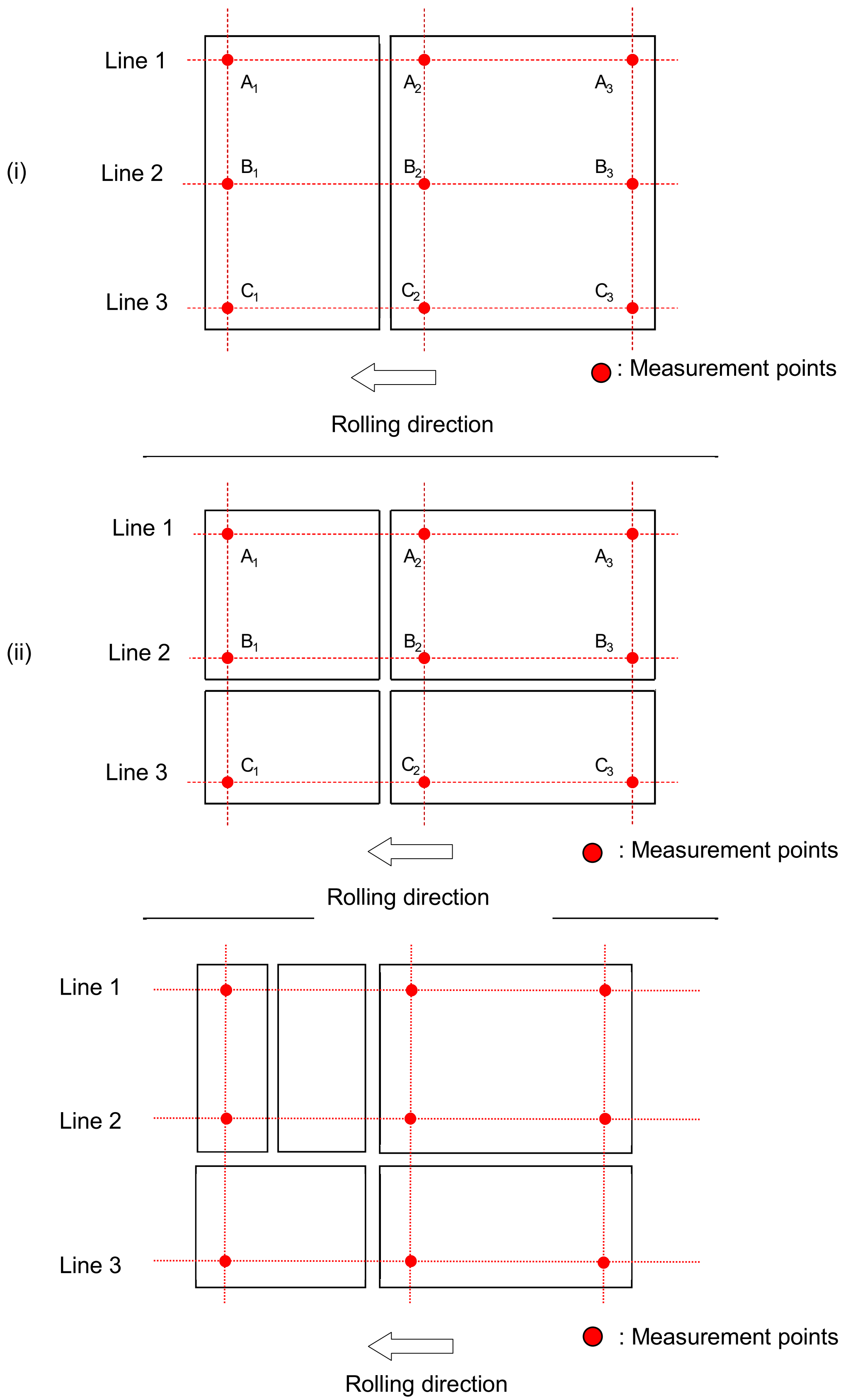



**Fig. 1.4.15.2a) : Locations of Thickness Measuring Points for the Original Steel Plates**

**Fig. 1.4.15.2b) : Locations of Thickness Measuring Points for the Cut Steel Products**



**1.5 Heat treatment, condition of supply**

1.5.1 All materials are to be supplied in the heat treated conditions described in the subsequent sections of this chapter unless supply in the as-rolled condition is allowed.

1.5.2 Where the material is supplied in the as rolled condition and intended for subsequent hot forming, the manufacturer is to carry out any heat treatment which may be necessary to prevent hydrogen cracking or make the material in a safe condition for transit and Surveyors are to be advised of any such heat treatment carried out. This requirement is applicable mainly to carbon and carbon-manganese steel products over 50 [mm] thick and to alloy steel products.

1.5.3 Where controlled rolling or thermo-mechanical processing is permitted as an alternative to normalising, these procedures may be used subject to full details being submitted and a test program being carried out under the supervision of the Surveyors and the test results being found satisfactory by Designated Authority/Classification Society. These rolling processes are defined as follows:

(See Fig.1.5.3).

a) As Rolled, AR - this procedure involves steel being cooled as it is rolled with no further heat treatment. The rolling and finishing temperatures are typically in the austenite recrystalisation region and above the normalising temperature. The strength and toughness properties of steel produced by this process are generally less than steel heat treated after rolling or than steel produced by advanced processes.

b) Normalising, N - normalising involves heating rolled steel above the critical temperature, Ac3 and in the lower end of the austenite recrystalisation region for a specific period of time, followed by air-cooling. The process improves the mechanical properties of as rolled steel by refining the grain size and homogenizing the microstructure.

c) Controlled rolling, CR (Normalizing Rolling, NR) - A rolling procedure in which the final deformation is carried out in the normalising temperature range, allowed to cool in air, resulting in a material condition generally equivalent to that obtained by normalising.

d) Quenching and Tempering, QT – Quenching involves a heat treatment process in which

   steel is heated to an appropriate temperature above the Ac3, held for specific period of time and then cooled with an appropriate coolant for the purpose of hardening the microstructure. Tempering subsequent to quenching is a process in which the steel is reheated to an appropriate temperature not higher than the Ac1, maintained at that temperature for a specific period of time to restore toughness properties by improving the microstructure and reduce the residual stress caused by the quenching process.

e) Thermo-mechanical Rolling, TM – Thermo-mechanical controlled processing - this is a procedure which involves the strict control of both the steel temperature and the rolling reduction. Generally, a high proportion of the rolling reduction is carried out close to or below the AR3 transition temperature and may involve rolling towards the lower end of the temperature range of the inter critical duplex phase region thus permitting little if any recrystallisation of the austenite. Unlike controlled rolled (normalised rolling) the properties conferred by TM (TMCP) cannot be reproduced by subsequent normalising or other heat treatment.

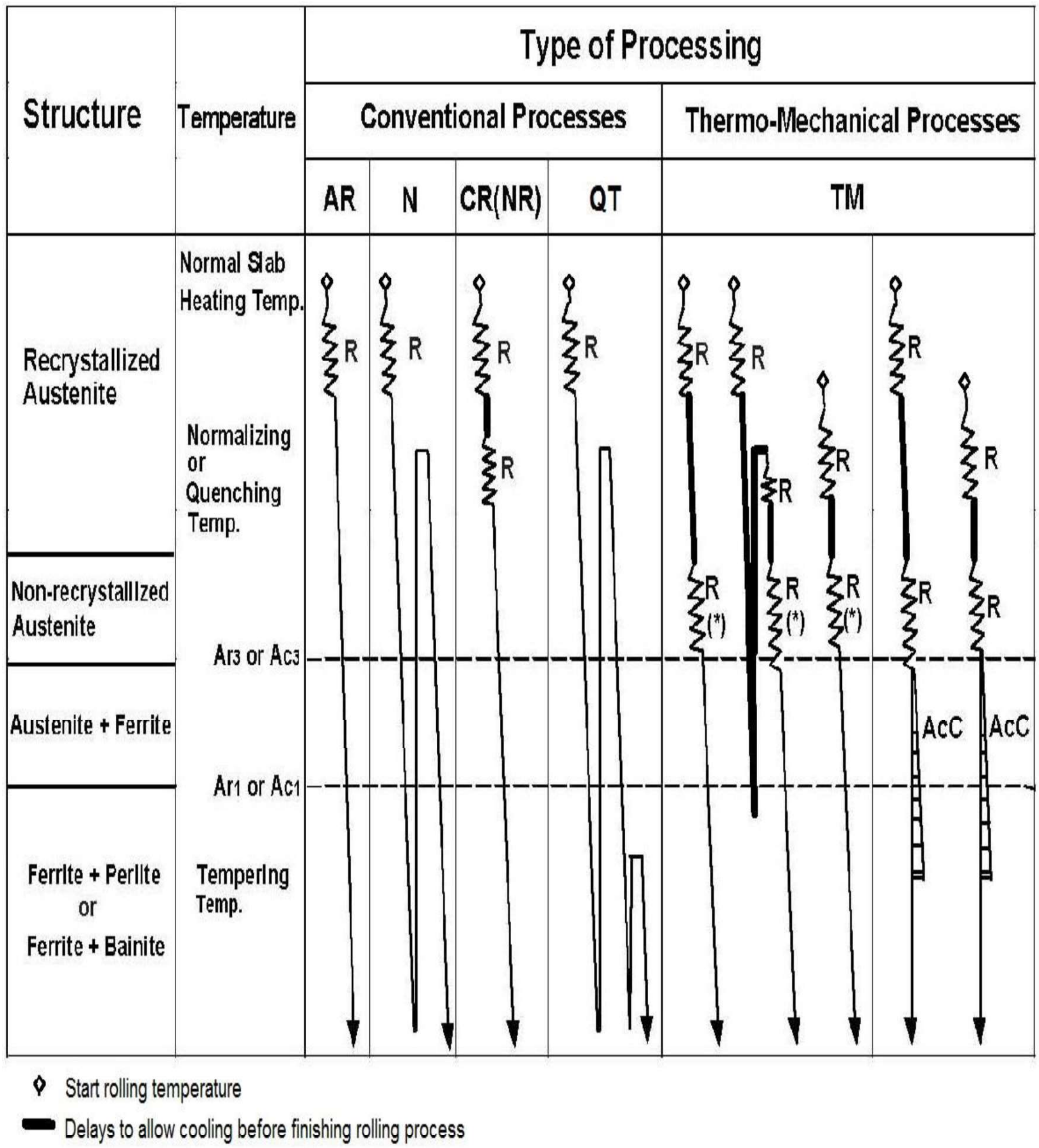
   The use of accelerated cooling on completion of TM-rolling may also be accepted subject to the special approval of Designated Authority/Classification Society. The same applies for use of tempering after completion of the TM-rolling.

f) Accelerated cooling AcC - accelerated cooling is a process, which aims to improve mechanical properties by controlled cooling with rates higher than air cooling immediately after the final TM-rolling operation. Direct quenching is excluded from the accelerated cooling.

   The material properties conferred by TM and AcC cannot be reproduced by subsequent normalising or other heat treatment.

1.5.3.1 Where NR (CR) and TM with/without AcC are applied, the programmed rolling schedules are to be verified by Designated Authority/Classification Society at the steel works and are to be made available when required by the attending Surveyor. On the manufacturer's responsibility, the programmed rolling schedules are to be adhered to during the rolling operation. (Refer 1.2.3). To this effect, all the records of actual rolling are to be reviewed by the manufacturer and occasionally by the Surveyor.

When deviation from the programmed rolling schedules or normalizing or quenching and tempering procedures occurs, the manufacturer shall take further measures required in 1.2.3 to the Surveyor's satisfaction.




Notes:

| | |
|---|---|
| AR: | As Rolled |
| N: | Normalizing |
| CR(NR): | Controlled Rolling (Normalizing Rolling) |
| QT: | Quenching and Tempering |
| TM: | Thermo-Mechanical Rolling (Thermo-Mechanical Controlled Process) |
| R: | Reduction |
| (*): | Sometimes rolling in the dual-phase temperature region of austenite and ferrite |
| AcC: | Accelerated Cooling |

**Fig.1.5.3 : Schematic Diagrams of Thermo-Mechanical and Conventional Processes**

1.5.3.2 The conditions of supply and the impact test requirements are detailed in subsequent sections of the Chapter.

**1.6 Test material**

1.6.1 All material in a batch presented for acceptance tests are to be of the same product form e.g. plates, flats, sections. etc., from the same cast and in the same condition of supply.

1.6.2 Test samples

a) The test samples are to be fully representative of the material and, where appropriate, are not to be cut from the material until heat treatment has been completed.

b) The test specimens are not to be separately heat treated in any way.

1.6.3 Unless otherwise agreed, the test samples are to be taken from the following position :

1.6.3.1 **Plates and flats with a width ≥ 600 [mm]** : The test samples are to be taken from one end at a position approximately midway between the axis in the direction of the rolling and the edge of the rolled product (See Fig.1.6.1 a). Unless otherwise agreed the tensile test specimens are to be prepared with their longitudinal axis transverse to the final direction of rolling.

1.6.3.2 **Flats with a width < 600 [mm], bulb flats and other sections** : For flats having a width of 600 [mm] or less, bulb flats and other sections the test specimens are to be taken from one end at a position approximately one third from the outer edge (See Figs.1.6.1 b,c,d), or in the case of small sections as near as possible to this position. In the case of channels, beams or bulb angles the test samples may alternatively be taken from a position approximately one quarter of the width from the web centreline or axis (See Fig.1.6.1 c). The tensile test specimens may be prepared with their longitudinal axis either parallel or transverse to the final direction of rolling.

1.6.3.3 **Bars and other similar products**: The test specimens are to be taken so that the axis of

the test specimen is parallel to the direction of rolling. For small sizes, the test specimen may consist of a suitable length of the full cross section of the product (the impact test specimen receiving nevertheless the necessary machining). For larger sizes, the test samples are to be taken so that the axis of the test specimen lies as near as possible to the following :

a) for non-cylindrical sections, at one third of the half diagonal from the outside.

b) for cylindrical sections, at one third of the radius from outside (See Fig.1.6.1 e).

1.6.3.4 For plates and flats with thicknesses in excess of 40 [mm], full thickness specimens may be prepared, but when instead a machined round specimen is used then the axis is to be located at a position lying one-quarter of the product thickness from the surface as shown in Fig.1.6.1.f.

**1.7 Mechanical test specimens**

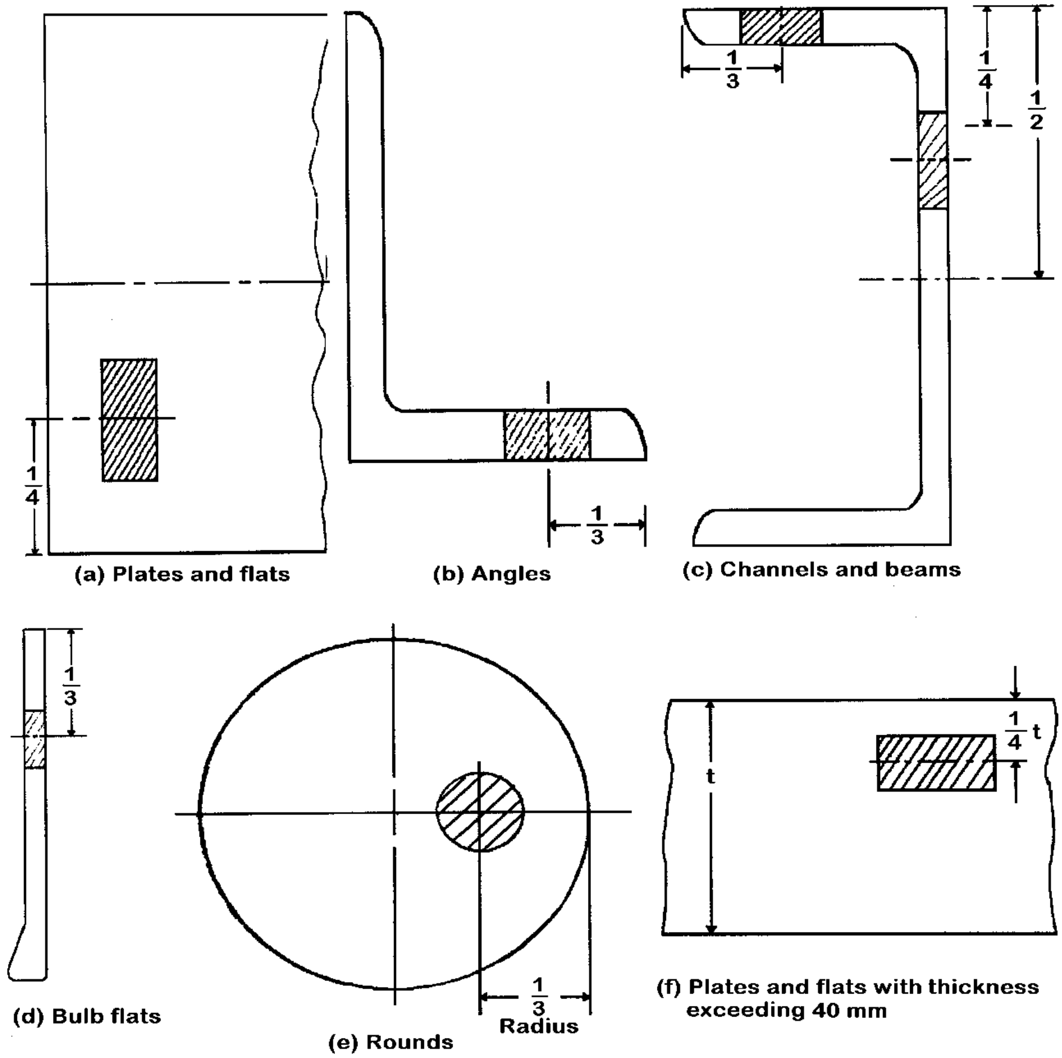



**Fig.1.6.1 : Samples for testing**

1.7.1 The tensile test specimens are to be machined to the dimensions detailed in Ch. 2.

1.7.2 Impact test specimens: The impact test specimens are to be of the charpy V-notch type machined to the dimensions detailed in Ch. 2 and cut with their longitudinal axis either parallel or transverse to the final direction of rolling of the material. They are to be taken from a position close to one of the rolled surfaces, except that for plates and sections over 40 [mm] thick the axis of test specimens are to be one quarter of the thickness from one of the rolled surfaces. For bars and other similar products the axis of the test specimens are to be as specified in 1.6.3.3. The notch is to be cut in a face of the test specimen which was originally perpendicular to the rolled surface. The position of the notch is to be not nearer than 25 [mm] to a flame-cut or sheared edge.

**1.8 Surface inspection and dimensions**

1.8.1 Surface inspection and verification of dimensions are the responsibility of the steel-maker, and acceptance by the Surveyors of material later found to be defective shall not absolve the steel maker from this responsibility. The manufacturer is also responsible for compliance with the general requirements concerning freedom from harmful internal defects.

**1.9 Freedom from defects**

1.9.1 All products must have a workmanlike finish and must be free from defects and imperfections which may impair their proper workability and use. This may however, include some discontinuties of a harmless nature, minor imperfections e.g. pittings, rolling in scale, indentations, roll marks, scratches and grooves which cannot be avoided completely despite proper manufacturing and which will not be objected to provided they do not exceed the acceptable limits contained herein.

1.9.2 **Imperfections** : Notwithstanding this, the products may have imperfections exceeding the discontinuities inherent to the manufacturing process, as defined under 1.9.1. In such cases, limits for their acceptability are to be agreed with Designated Authority/Classification Society, taking the end use of the product into consideration.

1.9.3 **Defects** : Cracks, shells, sand patches and sharp edged seams are always considered defects which would impair the end use of the product and which require rejection or repair, irrespective of their size and number. The same applies to other imperfection exceeding the acceptable limits.

**1.10 Special quality plate material ('z' quality)**

1.10.1 When plate material, intended for welded construction, will be subject to significant strains in a direction perpendicular to the rolled surfaces, it is recommended that consideration be given to the use of special plate material with specified through thickness properties. These strains are usually associated with thermal contraction and restraint during welding, particularly for full penetration "T"-butt welds, but may also be associated with loads applied in service or during construction. Requirements for these materials are detailed in Sec. 8 and it is the responsibility of shipbuilder or fabricator to make provision for the use of this material.

**1.11 Branding of materials**

1.11.1 Every finished item is to be clearly marked by the manufacturer in at least one place with and the following particulars:

a) The manufacturer's name or trade mark;

b) Identification mark for the grade of steel, (material supplied in the thermo-mechanically controlled process condition is to have the letter TM added after the identification mark) ;

c) Cast or identification number and/or initials which enable the full history of the item to be traced;

d) If required by the purchaser, his order number or other identification marks.

e) Steels, which have been specially approved and which differ from the requirements given in this Chapter are to have the letter "S" marked after the agreed identification mark.

f) Steel plates that have complied with the requirements for corrosion resistant steel will be identified by adding a corrosion designation to the unified identification mark for the grade of steel. The corrosion resistant steel is to be designated according to its area of application as follows:

- Lower surface of strength deck and surrounding structures; **RCU**
- Upper surface of inner bottom plating and surrounding structures; **RCB**
- For both strength deck and inner bottom plating; **RCW**

1.11.2 Products complying with the requirements of Sec. 8 are to be marked "Z 25" or 'Z 35' as appropriate, in addition to the material grade designation e.g. 'EH36Z25' or 'EH36Z35'.

1.11.3 The above particulars, but excluding the manufacturer's name or trade mark where this is embossed on finished products, are to be encircled with paint or otherwise marked so as to be easily recognizable.

1.11.4 In the event of any material failing to comply with the test requirements, the mark is to be unmistakably defaced.

**1.12 Test certificates or other documentation**

1.12.1 The Surveyor is to be supplied, in duplicate, copies of the test certificates or other documentation for all accepted materials, Designated Authority/Classification Society may require separate documents for each grade of steel. These documents are to contain, in addition to the description, dimensions, etc. of the material at least the following particulars:

a) Purchaser's order number and if known the ship number for which the material is intended;

b) Identification number and/or initials;

c) Identification of steel works;

d) Identification of the grade of steel;

e) Cast number and ladle analysis;

f) For steel with a corrosion resistant steel designation the weight percentage of each element added or intentionally controlled for improving corrosion resistance.

g) Condition of supply when other than as rolled e.g. normalized or controlled rolled;

h) If the material is of rimming quality, this should be stated;

i) Test results.

In the case of 'Z' quality steel, notation 'Z25' or 'Z35' as appropriate, is to be indicated with the steel grade and test results are to include through thickness reduction in area (%).

1.12.2 Before the test certificates or shipping statements are signed by the Surveyor, the manufacturer is required to furnish him with a written declaration stating that the material has been made by an approved process and that it has been subjected to and has withstood satisfactorily the required tests in the presence of the Surveyor or his authorized deputy. The following form of declaration will be accepted if stamped or printed on each test

certificate or shipping statement with the name of steelworks and initialed by the makers or an authorized deputy:

*"We hereby certify that the material has been made by an approved process and has been tested satisfactorily in the presence of the surveyors of Designated Authority/Classification Society".*

1.12.3 When steel is not produced at the works at which it is rolled a certificate is to be supplied to the Surveyor at the rolling mill stating the process by which it was manufactured and the name of the manufacturer, the number of cast from which it was made and the ladle analysis. The Surveyors are to have access to the works at which the steel was produced and the works must be approved by Designated Authority/Classification Society. Also refer Chapter 1, Section1, Cl. 1.3.2.

## Section 2

## Normal Strength Steels for Ship Structures

### 2.1 General

2.1.1 Requirements of this section are applicable to weldable normal strength hot-rolled steel plates, wide flats, sections and bars intended for use in hull construction. Steel differing in chemical composition, deoxidation practice, heat treatment or mechanical properties may be accepted, subject to special agreement by Designated Authority/Classification Society.

2.1.2 These requirements are primarily intended to apply to steel plates and wide flats not exceeding 100 [mm] in thickness and sections and bars not exceeding 50 [mm] in thickness. For greater thickness, certain variations in the requirements may be allowed or required in particular cases after consideration of the technical circumstances involved.

### 2.2 Approval

2.2.1 Normal strength steel for ship hull structure is to be approved in accordance with requirements given in Section 1.

### 2.3 Method of Manufacture

2.3.1 Steel is to be manufactured by the basic oxygen, electric furnace or open hearth processes or by other processes specially approved.

2.3.2 The definitions of applicable rolling procedures and the schematic diagrams are given in Sec 1.

2.3.3 The de-oxidation practice used for each grade is to comply with the appropriate requirements of Table 2.4.1.

2.3.4 The rolling practice applied for each grade is to comply with the appropriate condition of supply of Table 2.5.1

### 2.4 Chemical composition

2.4.1 The chemical composition of samples taken from each ladle of each cast is to be determined by the manufacturer in an adequately equipped and competently staffed laboratory and is to comply with appropriate requirements of Table 2.4.1. For steel plates and wide flats over 50 [mm] thick, slight deviations in the chemical composition may be allowed as approved by Designated Authority/Classification Society.

2.4.2 The manufacturer's declared analysis will be accepted subject to occasional checks if required by the surveyor.

### 2.5 Condition of supply

2.5.1 All materials are to be supplied in a condition complying with Table 2.5.1 and Table 2.5.2. Where alternative arrangements are permitted these are at the option of the steelmaker, unless otherwise expressly stated in the order for the material.

### 2.6 Mechanical Properties

2.6.1 For tensile test either the upper yield stress (ReH) or where ReH cannot be determined, the 0.2 percent proof stress (Rp 0.2) is to be determined and the material is considered to comply with the requirements if either value meets or exceeds the specified minimum value for yield strength (Re).

2.6.2 Results obtained from tensile tests are to comply with the appropriate requirements of Table 2.6.1.

2.6.3 Minimum average energy values are specified for Charpy V-notch impact test specimens taken in either the longitudinal or transverse directions. Generally, only longitudinal test specimens need be prepared and tested except for special applications where transverse test specimens may be required. Transverse test results are to be guaranteed by the manufacturer. The tabulated values are for standard specimens 10 [mm] x 10 [mm]. For plate thicknesses lower than 10 [mm], sub-size specimens may be used with reduced requirements as follows:

Specimen 10 x 7.5 [mm] : 5/6 of tabulated energy

Specimen 10 x 5 [mm] : 2/3 of tabulated energy.

2.6.4 For impact tests, the average value obtained from one set of three impact tests is to comply with the requirements given in Table 2.6.1. One individual value may be less than the required average value provided that it is not less than 70 per cent of this average value. See also Chapter 1.

2.6.5 Generally, impact tests are not required when the nominal plate thickness is less than 6 [mm].

**Table 2.4.1 : Deoxidation and chemical composition**

| Grade | A | B | D | E |
|---|---|---|---|---|
| Deoxidation practice | For t ≤ 50 mm Any method except rimmed steel[1] | For t ≤ 50 mm Any method except rimmed steel | For t ≤ 25 [mm] killed, | Killed and fine grain treated |
| | For t > 50 mm Killed | For t > 50 mm Killed | For t > 25 mm Killed and fine grain treated | |
| Chemical composition per cent [4,7,8] (ladle samples) | | | | |
| Carbon max. | 0.21[2] | 0.21 | 0.21 | 0.18 |
| Manganese min | 2.5 x Carbon % | 0.80[3] | 0.60 | 0.70 |
| Silicon max | 0.50 | 0.35 | 0.35 | 0.10 - 0.35 |
| Phosphorus max | 0.035 | 0.035 | 0.035 | 0.035 |
| Sulphur max | 0.035 | 0.035 | 0.035 | 0.035 |
| Aluminium (acid soluble min) | - | - | 0.015[5,6] | 0.015[6] |
| Carbon + 1/6 of the manganese content is not to exceed 0.40 per cent | | | | |

**Notes :**

1 Grade A sections up to thickness of 12.5 mm may be accepted in rimmed steel subject to the special approval of Designated Authority/Classification Society.

2 Max. 0.23% for sections.

3 When Grade B steel is impact tested the minimum manganese content may be reduced to 0.60%

4 When any grade of steel is supplied in the thermo-mechanically rolled condition variations in the specified chemical composition may be allowed or required by Designated Authority/Classification Society.

5 Aluminium is required for thickness above 25 [mm].

6 The total aluminium content may be determined instead of the acid soluble content. In such cases the total aluminium content is to be not less than 0.020 per cent.

7 Designated Authority/Classification Society may limit the amount of residual/trace elements which may have an adverse effect on the working and use of the steel, e.g. copper and tin.

8 Where additions of any other element have been made as part of the steelmaking practice, the content is to be specified.

**Table 2.5.1 : Condition of supply for normal strength steel (1)**

| Grades | Thickness | Condition of supply |
|---|---|---|
| A | ≤ 50 mm | Any |
| | > 50 mm ≤ 100 mm | Normalized, controlled rolled or thermo-mechanically rolled (2) |
| B | ≤ 50 mm | Any |

| | | |
|---|---|---|
| | > 50 mm ≤ 100 mm | Normalized, controlled rolled or thermo-mechanically rolled (2) |
| D | ≤ 35 mm | Any |
| | > 35 mm ≤ 100 mm | Normalized, controlled rolled or thermo-mechanically rolled (3) |
| E | ≤ 100 mm | Normalized or thermo-mechanically rolled (3) |

**Notes:**

1) These conditions of supply and the impact test requirements are summarised in Table 2.5.2
2) Subject to the special approval of Designated Authority/Classification Society, Grades A and B steel plates may be supplied in the as rolled condition. See 2.14.2.2.
3) Subject to the special approval of Designated Authority/Classification Society, sections in Grade D steel may be supplied in the as rolled condition provided satisfactory results are consistently obtained from Charpy V-notch impact tests. Similarly sections in Grade E steel may be supplied in the as rolled or controlled rolled condition. For the frequency of impact tests see 2.14.3.2 and 2.14.3.3.

**Table 2.5.2 : Required condition of supply and number of impact tests for normal strength steels**

| Grade | Deoxidation Practice | Pro-ducts | Condition of supply (batch for impact tests) (1)(2) | | | | |
|---|---|---|---|---|---|---|---|
| | | | Thickness [mm] | | | | |
| | | | 10 12.5 20 25 30 35 40 50 100 | | | | |
| A | Rimmed | Sections | A(-) | Not applicable | | | |
| A | For t ≤ 50 mm<br>Any method except rimmed<br>For t > 50 mm<br>Killed | Plates | A(-) | | | | N(-)<br>TM(-)$^3$<br>CR(50), AR*(50) |
| | | Sections | A(-) | | | | Not applicable |
| B | For t ≤ 50 mm<br>Any method except rimmed<br>For t > 50 mm<br>Killed | Plates | A(-) | | A(50) | | N(50)<br>TM(50)<br>CR(25), AR*(25) |
| | | Sections | A(-) | | A(50) | | Not applicable |
| D | Killed | Plates<br>Sections | A(50) | | | Not applicable | |
| D | Plates<br>Killed and fine grain treated | Plates | A(50) | | | N(50)<br>CR(50)<br>TM(50) | N(50)<br>TM(50)<br>CR(25) |
| D | | Sections | A(50) | | | N(50)<br>CR(50)<br>TM(50)<br>AR*(25) | Not applicable |
| E | Killed and fine grain treated | Plates | N(Each piece)<br>TM(Each piece) | | | | |
| | | Sections | N(25)<br>TM(25)<br>AR*(15), CR*(15) | | | Not applicable | |

Remarks:

1. Condition of Supply

A - Any (Not Specified)

N - Normalised Condition

CR - Controlled Rolled Condition

TM - Thermo-Mechanical Rolling

AR* - As Rolled Condition subject to special approval of Designated Authority/Classification Society

CR* - Controlled Rolled Condition subject to special approval of Designated Authority/Classification Society.

2. Number of Impact Tests

One set of impact tests is to be taken from each batch of the specified weight in ( ) in tones or fraction thereof.

3. See Note 5 of Table 2.6.1

**Table 2.6.1 : Mechanical properties for normal strength steels**

| Grade | Yield strength ReH [N/mm²] min. | Tensile strength Rm [N/mm²] | Elon-gation $5.65\sqrt{S_o}$ A5 (%) | Impact Test | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Test Temp. °C | Average impact energy (J) min. | | | | | |
| | | | | | t ≤ 50 mm | | 50 < t ≤ 70 mm | | 70 < t ≤ 100 mm | |
| | | | | | Long (3) | Trans (3) | Long (3) | Trans (3) | Long (3) | Trans (3) |
| A | 235 | 400/520 (1) | 22(2) | +20 | - | - | 34(5) | 24(5) | 41(5) | 27(5) |
| B | | | | 0 | 27(4) | 20(4) | 34 | 24 | 41 | 27 |
| D | | | | -20 | 27 | 20 | 34 | 24 | 41 | 27 |
| E | | | | -40 | 27 | 20 | 34 | 24 | 41 | 27 |

Notes:

4) For all thicknesses of Grade A sections the upper limit for the specified tensile strength range may be exceeded at the discretion of Designated Authority/Classification Society.

5) For full thickness flat tensile test specimens with a width of 25 mm and a gauge length of 200 mm the elongation is to comply with the following minimum values:

| Thickness [mm] | | > 5 | > 10 | > 15 | > 20 | > 25 | > 30 | > 40 |
|---|---|---|---|---|---|---|---|---|
| | ≤ 5 | ≤ 10 | ≤ 15 | ≤ 20 | ≤ 25 | ≤ 30 | ≤ 40 | ≤ 50 |
| Elongation | 14 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |

6) See 2.6.3.

7) Charpy V-notch impact tests are generally not required for Grade B steel with thickness of 25 mm or less.

8) Impact tests for Grade A over 50 mm thick are not required when the material is produced using fine grain practice and furnished normalised. TM rolling may be accepted without impact testing at the discretion of Designated Authority/Classification Society.

**2.7 Surface Quality**

2.7.1 The steel is to be free from surface defects prejudicial to the use of the material for the intended application. The finished material is to have a surface quality in accordance with a recognized standard such as EN 10163 parts 1, 2 and 3, or an equivalent

standard accepted by Designated Authority/Classification Society, unless otherwise specified in this section.

2.7.2 The responsibility for meeting the surface finish requirements rests with the manufacturer of the material, who is to take the necessary manufacturing precautions and is to inspect the products prior to delivery. At that stage, however, rolling or heat treatment scale may conceal surface discontinuities and defects. If, during the subsequent descaling or working operations, the material is found to be defective, Designated Authority/Classification Society may require materials to be repaired or rejected.

2.7.2.1 The surface quality inspection method is to be in accordance with recognized national or international standards agreed between purchaser and manufacturer, accepted by Designated Authority/Classification Society.

2.7.2.2 If agreed between the manufacturer and purchaser, steel may be ordered with improved surface finish over and above these requirements.

2.7.3 Acceptance Criteria

2.7.3.1 Imperfections

2.7.3.1.1 Imperfections of a harmless nature, for example pitting, rolled-in scale, indentations, roll marks, scratches and grooves, regarded as being inherent of the manufacturing process, are permissible irrespective of their number, provided

the maximum permissible limits of Class A of EN 10163-2 or limits specified in a recognized equivalent standard accepted by Designated Authority/Classification Society, are not exceeded and the remaining plate or wide flat thickness remains within the average allowable minus thickness tolerance specified in Sec 1, 1.4. Total affected area with imperfection not exceeding the specified limits are not to exceed 15 % of the total surface in question.

2.7.3.2 Defects

2.7.3.2.1 Affected areas with imperfections with a depth exceeding the limits of Class A of EN 10163-2 or the maximum permissible limits specified in a recognized equivalent standard accepted by Designated Authority/Classification Society, are to be repaired irrespective of their number. Cracks, injurious surface flaws, shells (over lapping material with non-metallic inclusion), sand patches, laminations and sharp edged seams (elongated defects) visually evident on surface and/or edge of plate are considered defects, which would impair the end use of the product and which require rejection or repair, irrespective of their size and number.

2.7.4 Repair

2.7.4.1 Grinding repair

2.7.4.1.1 Grinding may be applied provided all the conditions below are adhered to:

(a) The nominal product thickness will not be reduced by more than 7% or 3 mm, whichever is the less.

(b) Each single ground area does not exceed 0.25 [$m^2$].

(c) All ground areas do not exceed 2% of the total surface in question.

(d) Ground areas lying in a distance less than their average breadth to each other are to be regarded as one single area.

(e) Ground areas lying opposite each other on both surfaces are not to decrease the product thickness by values exceeding the limits as indicated in (a).

Defects or unacceptable imperfections are to be completely removed by grinding and the remaining plate or wide flat thickness is to remain within the average allowable minus thickness tolerance specified in Sec.1, 1.4. The ground areas are to be a smooth transition to the surrounding surface of the product. Complete elimination of the defect is to be verified by magnetic particle or by liquid penetrant testing.

2.7.4.2 Welding repair

2.7.4.2.1 Weld repair procedures and the method are to be reported and be approved by the Designated Authority/Classification Society. Repair of defects such as unacceptable imperfections, cracks, shells or seams are to be followed by magnetic particle or liquid penetrant testing. Local defects which cannot be repaired by grinding as stated in 2.7.4.1 may be repaired by welding with the agreement of Designated Authority/Classification Society subject to the following conditions:

(a) Any single welded area is not to exceed 0.125 [$m^2$] and the sum of all areas is not to exceed 2% of the surface side in question.

(b) The distance between two welded areas is not to be less than their average width.

(c) The weld preparation is not to reduce the thickness of the product below 80% of the nominal thickness. For occasional defects with depths exceeding the 80% limit, special consideration at the Surveyor's discretion will be necessary.

(d) If weld repair depth exceeds 3 [mm], UT may be requested by Designated Authority/Classification Society. If required, UT is to be carried out in accordance with an approved procedure.

(e) The repair is to be carried out by qualified welders using an approved procedure for the appropriate steel grade. The electrodes are to be of low hydrogen

type and are to be dried in accordance with the manufacturer's requirements and protected against re-humidification before and during welding.

2.7.5 The surface quality and condition requirement herein are not applied to products in forms of bars and tubulars, which will be subject to manufacturers' conformance standards.

**2.8 Internal soundness**

2.8.1 If plates and wide flats are ordered with ultrasonic inspection, this is to be made in accordance with an accepted standard at the discretion of Designated Authority/Classification Society.

2.8.2 Verification of internal soundness is the responsibility of the manufacturer. The acceptance of internal soundness by surveyor does not absolve the manufacturer from this responsibility.

**2.9 Tolerances**

2.9.1 Unless otherwise agreed or specially required the thickness tolerances as per Sec.1, 1.4 are applicable.

**2.10 Identification of Materials**

2.10.1 The steelmaker is to adopt a system for the identification of ingots, slabs and finished pieces which will enable the material to be traced to its original cast.

2.10.2 The Surveyor is to be given full facilities for so tracing the material when required.

**2.11 Testing and Inspection**

2.11.1 Facilities for Inspection

2.11.1.1 The manufacturer is to afford the Surveyor all necessary facilities and access to all relevant parts of the works to enable him to verify that the approved process is adhered to, for the selection of test materials, and the witnessing of tests, as required by the requirementss, and for verifying the accuracy of the testing equipment.

2.11.2 Testing Procedures

2.11.2.1 The prescribed tests and inspections are to be carried out at the place of manufacture before dispatch. The test specimens and procedures are to be in accordance with Ch.2. All the test specimens are to be selected and stamped by the Surveyor and tested in his presence, unless otherwise agreed.

2.11.3 Through Thickness Tensile Tests

2.11.3.1 If plates and wide flats with thickness of 15 [mm] and over are ordered with through thickness properties, the through thickness tensile test in accordance with Sec.8 is to be carried out.

2.11.4 Dimensions

2.11.4.1 Verification of dimensions are the responsibility of the steel maker. The acceptance by Surveyor does not absolve the steel maker from this responsibility.

**2.12 Test Material**

2.12.1 Definitions

2.12.1.1 Refer to Ch1 for the definitions of piece and batch.

2.12.2 Test Samples

2.12.2.1 Refer to Sec 1, for the requirements related to test samples.

**2.13 Mechanical Test specimens**

2.13.1 Tensile Test Specimens. The dimensions of the tensile test specimens are to be in accordance with Ch.2. Generally, for plates, wide flats and sections flat test specimens of full product thickness are to be used. Round test specimens may be used when the product thickness exceeds 40 [mm] or for bars and other similar products. Alternatively, for small sizes of bars, etc. test specimens may consist of a suitable length of the full cross section of the product.

2.13.2 Impact Test Specimens. The impact test specimens are to be of the Charpy V-notch type cut with their edge within 2 [mm] from the "as rolled" surface with their longitudinal axes either parallel (indicated "Long" in Table 2.6.1) or transverse (indicated "Trans" in Tables 2.6.1) to the final direction of rolling of the material. The notch is to be cut in a face of the test specimen which was originally perpendicular to the rolled surface. The position of the notch is not to be nearer than 25 [mm] to a flame cut or sheared edge (see also 2.6.3). Where the product thickness exceeds 40 [mm], the impact test specimens are to be taken with their longitudinal axis at a quarter thickness position.

**2.14 Number of Test Specimens**

2.14.1 Number of Tensile Tests

2.14.1.1 For each batch presented. except where specially agreed by Designated Authority/Classification Society. one tensile test is to be made from one piece unless the weight of finished material is greater than 50 tonnes in which case one extra test piece is to be made from a different piece from each 50 tonnes or fraction thereof. Additional tests are to be made for every variation of 10 [mm] in thickness of plate or diameter of products from the same cast. For sections the thickness to be considered is the thickness of the product at the point at which samples are taken for mechanical tests.

2.14.2 Number of Impact Tests (except for Grade E)

2.14.2.1 For each batch presented, except where specially agreed by Designated Authority/ Classification Society at least one set of three

Charpy V-notch test specimens is to be made from one piece unless the weight of finished material is greater than 50 tonnes in which case one extra set of

three test specimens is to be made from a different piece from each 50 tonnes or fraction thereof. The piece selected for the preparation of test specimen is to be the thickest of each batch. Where steel plates except for Grade 'A' steel over 50 [mm] in thickness is supplied in the controlled rolled condition, the frequency of impact test is to be made from a different piece from each 25 tonnes or fraction thereof.

2.14.2.2 When subject to the special approval of Designated Authority/Classification Society, material is supplied in the as rolled condition the frequency of impact tests is to be increased to one set from each batch of 25 tonnes or fraction thereof. However, for Grade 'A' steel over 50 [mm] thickness when supplied in the "as rolled" condition, one set of three charpy V-notch test specimens may be taken from each batch of 50 tonnes or fraction thereof.

2.14.2.3 The piece selected for the preparation of the test specimens is to be the thickest in each batch.

2.14.3 Number of Impact Tests (for Grade E)

2.14.3.1 For steel plates supplied in the normalized or TM condition, one set of impact test specimens is to be taken from each piece.

2.14.3.2 For sections, one set of impact tests is to be taken from each batch of 25 tonnes or fraction thereof.

2.14.3.3 When, subject to the special approval of Designated Authority/Classification Society, sections are supplied in the as-rolled or controlled rolled condition.one set of impact tests is to be taken from each batch of 15 tonnes or fraction thereof.

2.14.3.4 For 2.14.3.2 and 2.14.3.3 above the piece selected for the preparation of the test specimens is to be the thickest in each batch.

**2.15 Retest Procedures**

2.15.1 Retest procedures are to be as per the requirements provided in Chapter 1.

## Section 3

## Higher Strength Steels for Ship Structures

**3.1 General**

3.1.1 Requirements of this section is applicable to weldable higher strength hot-rolled steel plates, wide flats, sections and bars intended for use in hull construction.

3.1.2 The requirements of this section are primarily intended to apply to plates and wide flats not exceeding 100 [mm] in thickness in general, and sections and bars not exceeding 50 [mm] in thickness. For greater thickness, these requirements may be applied with certain variations, as may be agreed by Designated Authority/Classification Society.

3.1.3 Steel differing in chemical composition, deoxidation practice, heat treatment or mechanical properties may be accepted, subject to special approval by Designated Authority/Classification Society. Such steel is to be given special designation.

3.1.4 Provision is made for three strength levels (315, 355 and 390 N/mm$^2$) each subdivided into four grades, AH, DH, EH and FH based on impact test temperature.

The additional requirements for high strength plates having specified minimum yield point of 460 [N/mm$^2$] with thickness over 50 [mm] and not greater than 100 [mm] for use in longitudinal structural members in the upper deck region of container ships (such as hatch side coaming, hatch coaming, hatch coaming top and attached longitudinals) and denoted by Grade EH47 are also given in this section.

**3.2 Approval**

3.2.1 Higher strength steel for ship hull structure is to be approved in accordance with requirements given in Section 1.

3.2.2 It should be noted that when fatigue loading is present, the effective fatigue strength of a welded construction of higher strength steels may not be greater than that of a construction fabricated from the normal strength steels. Precautions against corrosion fatigue may also be necessary.

Note: Before subjecting steels produced by thermo-mechanical rolling to further heating for forming or stress relieving or using high heat-input welding, special consideration must be given to the possibility of a consequent reduction in mechanical properties.

**3.3 Method of Manufacture**

3.3.1 Steel is to be manufactured by the basic oxygen, electric furnace or open hearth processes or by other processes specially approved by Designated Authority/Classification Society.

3.3.2 The definitions of applicable rolling procedures and the schematic diagrams are given in Sec 1.

3.3.3 The deoxidation practice used for each grade is to comply with the appropriate requirements of Table 3.4.1.

3.3.4 The rolling practice applied for each grade is to comply with the appropriate condition of supply of Table 3.5.1

**3.4 Chemical composition**

3.4.1 The chemical composition of samples taken from each ladle of each cast is to be determined by

the manufacturer in an adequately equipped and competently staffed laboratory and is to comply with appropriate requirements of Table 3.4.1. For steel plates and wide flats over 50 [mm] thick, slight deviations in the chemical composition may be allowed as approved by Designated Authority/Classification Society.

The chemical composition of EH 47 steel plates would be specially considered.

3.4.2 The manufacturer's declared analysis will be accepted subject to occasional checks if required by the surveyor.

3.4.3 When required, the carbon equivalent value is to be calculated from the ladle analysis using the following formula.

$$\text{Carboneq.} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}\ \%$$

Note: This formula is applicable only to steels which are basically of the carbon manganese type and gives a general indication of the weldability of the steel.

**Table 3.4.1 : Chemical composition and deoxidation practice for higher strength steels**

| **Grade[1)]** | **AH32/DH32/EH32**<br>**AH36/DH36/EH36**<br>**AH40/DH40/EH40** | **FH32**<br>**FH36**<br>**FH40** | **EH47** |
|---|---|---|---|
| Deoxidation practice | Fully killed and fine grain refined | | |
| Chemical Composition per cent (Ladle sample)[5),6)] | | | |
| C max. | 0.18 | 0.16 | 0.18 |
| Mn | 0.90 - 1.60[2)] | 0.90 - 1.60 | 0.9 – 2.00 |
| Si max. | 0.50 | 0.50 | 0.55 |
| P max. | 0.035 | 0.025 | 0.020 |
| S max. | 0.035 | 0.025 | 0.020 |
| Grain refining elements[5)] | | | |
| Al (acid soluble) min. | 0.015[3),4)] | | |
| Nb | 0.02 - 0.05[4)] | | |
| V | 0.05 - 0.10[4)] | | |
| Ti max. | 0.02 | | |
| Total (Nb + V + Ti) | 0.12 max. | | |
| Residual elements | | | |
| Cu max. | 0.35 | 0.35 | 0.35 |
| Cr max. | 0.20 | 0.20 | 0.25 |
| Ni max. | 0.40 | 0.80 | 1.0 |
| Mo max. | 0.08 | 0.08 | 0.08 |
| N max. | - | 0.009 (0.012 if Al is present) | - |

Notes:

1) The number following the grade designation indicates the yield point to which the steel is ordered or produced in [$Kg/mm^2$].

2) For thickness upto and including 12.5 [mm] the minimum manganese content may be reduced to 0.70 percent.

3) The total aluminium content may be determined instead of the acid soluble content. In such cases the total aluminium content is to be not less than 0.020 percent

4) The steel is to contain aluminium, niobium, vanadium or other suitable grain refining elements, either single or in combination. When used singly the steel is to contain the specified minimum content of the grain refining element. When used in combination, the specified minimum content of a fine graining element is not applicable.

5) When any grade of higher strength steel is supplied in the thermo-mechanically rolled condition variations in the specified chemical composition may be allowed or required by Designated Authority/Classification Society

6) Where additions of any other element have been made as part of the steel making practice, the content is to be indicated.

3.4.4 For TM (TMCP) steels the following special requirements apply:

i) The carbon equivalent value is to be calculated

from the ladle analysis using the following formula and to comply with the requirements of the following table:

| Carbon equivalent for higher strength steels upto 100 mm in thickness produced by TM | | |
|---|---|---|
| Grade | Carbon equivalent Max. (%)[1] | |
| | $t \leq 50$ | $50 < t \leq 100$ |
| AH32, DH32, EH32, FH32 | 0.36 | 0.38 |
| AH36, DH36, EH36, FH36 | 0.38 | 0.40 |
| AH40, DH40, EH40, FH40 | 0.40 | 0.42 |
| EH47 | NA | 0.49 |
| t = thickness [mm] | | |

Note:

1) It is a matter for the manufacturer and shipbuilder to mutually agree in individual cases as to whether they wish to specify a more stringent carbon equivalent.

$$\text{Carbon eq.} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} \ \%$$

ii) Other means such as cold cracking susceptibility $P_{cm}$ (in %), may be considered instead of the carbon equivalent for evaluating the weldability.

$$P_{cm} = C + \frac{Si}{30} + \frac{Mn}{20} + \frac{Cu}{20} + \frac{Ni}{60} + \frac{Cr}{20} + \frac{Mo}{15} + \frac{V}{10} + 5B$$

3.4.5 The carbon equivalent of EH47 grade steel calculated as per 3.4.3 is not to exceed 0.49%. The cold cracking susceptibility $P_{cm}$ calculated using the formula mentioned in 3.4.4.(ii) is not to exceed 0.22%.

### 3.5 Condition of supply

3.5.1 All materials are to be supplied in a condition complying with the requirements given in Table 3.5.1.

**Table 3.5.1 : Condition of supply for Higher strength steel [1)]**

| Grades | Grain Refining Elements Used | Thickness | Condition of supply |
|---|---|---|---|
| A32<br>A36 | Nb and/or V | $\leq$ 12.5 mm | Any |
| | | > 12.5 mm $\leq$ 100 mm | Normalized, controlled rolled or thermo-mechanically rolled [(3)] |
| | Al alone or with Ti | $\leq$ 20 mm | Any |
| | | > 20 mm $\leq$ 35 mm | Any, as rolled subject to special approval of Designated Authority/Classification Society [(2)] |
| | | > 35 mm $\leq$ 100 mm | Normalized, controlled rolled or thermo-mechanically rolled [(3)] |

| | | | |
|---|---|---|---|
| A40 | Any | ≤ 12.5 mm | Any |
| | | > 12.5 mm ≤ 50 mm | Normalized, controlled rolled or thermo-mechanically rolled |
| | | > 50 mm ≤ 100 mm | Normalized, thermo-mechanically rolled or quenched and tempered |
| D32<br>D36 | Nb and/or V | ≤ 12.5 mm | Any |
| | | > 12.5 mm ≤ 100 mm | Normalized, controlled rolled or thermo-mechanically rolled (3) |
| | Al alone or with Ti | ≤ 20 mm | Any |
| | | > 20 mm ≤ 25 mm | Any, as rolled subject to special approval of Designated Authority/Classification Society (2) |
| | | > 25 mm ≤ 100 mm | Normalized, controlled rolled or thermo-mechanically rolled (3) |

**Table 3.5.1 : (Contd.)**

| Grades | Grain Refining Elements Used | Thickness | Condition of supply |
|---|---|---|---|
| D40 | Any | ≤ 50 mm | Normalized, controlled rolled or thermo-mechanically rolled |
| | | > 50 mm ≤ 100 mm | Normalized, thermo-mechanically rolled or quenched and tempered |
| E32<br>E36 | Any | ≤ 50 mm | Normalized or thermo-mechanically rolled (3) |
| | | > 50 mm ≤ 100 mm | Normalized, thermo-mechanically rolled |
| E40 | Any | ≤ 50 mm | Normalized, thermo-mechanically rolled or quenched and tempered |
| | | > 50 mm ≤ 100 mm | Normalized, thermo-mechanically rolled or quenched and tempered |
| F32<br>F36<br>F40 | Any | ≤ 50 mm | Normalized, thermo-mechanically rolled or quenched and tempered (4) |
| | | > 50 mm ≤ 100 mm | Normalized, thermo-mechanically rolled or quenched and tempered |

Notes:

(1) These conditions of supply and the requirements for impact tests are summarised in Table 3.5.2.

(2) The frequency of impact tests is to be in accordance with 3.14.2 (ii).

(3) Subject to the special approval of Designated Authority/Classification Society, sections in Grades AH32, AH36, DH32 and DH36 steels may be supplied in the as rolled condition provided satisfactory results are consistently obtained from Charpy V-notch impact tests. Similarly sections in Grades EH32 and EH36 steels maybe supplied in the as rolled or controlled rolled condition. The frequency of impact tests is to be in accordance with 3.14.2 (ii) and 3.14.2 (iii) respectively.

(4) Subject to the special approval of Designated Authority/Classification Society, sections in Grades FH32 and FH36 steels may be supplied in the controlled rolled condition. The frequency of impact tests is to be in accordance with 3.14.3 (iii).

**Table 3.5.2 : Required condition of supply and number of impact tests for higher strength steels**

<table>
<tr><th rowspan="3">Grade</th><th rowspan="3">Deoxi-dation Practice</th><th rowspan="3">Grain Refining Elements</th><th rowspan="3">Pro-ducts</th><th colspan="5">Condition of supply (batch for impact tests) (1)(2)</th></tr>
<tr><th colspan="5">Thickness [mm]</th></tr>
<tr><th colspan="5">10 12.5 20 25 30 35 40 50 100</th></tr>
<tr><td rowspan="5">AH32<br>AH36</td><td rowspan="5">Killed and fine grain treated</td><td rowspan="2">Nb and/or V</td><td>Plates</td><td>A(50)</td><td colspan="3">N(50)<br>CR(50),TM(50)</td><td>N(50),CR(25),<br>TM(50)</td></tr>
<tr><td>Sections</td><td>A(50)</td><td colspan="3">N(50)<br>CR(50),TM(50)<br>AR*(25)</td><td>Not applicable</td></tr>
<tr><td rowspan="3">Al alone or with Ti</td><td rowspan="2">Plates</td><td colspan="2" rowspan="2">A(50)</td><td>AR*(25)</td><td colspan="2">Not applicable</td></tr>
<tr><td colspan="2">N(50), CR(50)<br>TM(50)</td><td>N(50), CR(25)<br>TM(50)</td></tr>
<tr><td>Sections</td><td colspan="2">A(50)</td><td colspan="2">N(50)<br>CR(50)<br>TM(50)<br>AR*(25)</td><td>Not applicable</td></tr>
<tr><td rowspan="2">AH40</td><td rowspan="2">Killed and fine grain treated</td><td rowspan="2">Any</td><td>Plates</td><td>A(50)</td><td colspan="3">N(50)<br>CR(50)<br>TM(50)</td><td>N(50)<br>TM(50)<br>QT (Each length as heat treated)</td></tr>
<tr><td>Sections</td><td>A(50)</td><td colspan="3">N(50)<br>CR(50)<br>TM(50)</td><td>Not applicable</td></tr>
<tr><td rowspan="5">DH32<br>DH36</td><td rowspan="5">Killed and fine grain treated</td><td rowspan="2">Nb and/or V</td><td>Plates</td><td>A(50)</td><td colspan="3">N(50)<br>CR(50),TM(50)</td><td>N(50),CR(25),TM(50)</td></tr>
<tr><td>Sections</td><td>A(50)</td><td colspan="3">N(50)<br>CR(50),TM(50)<br>AR*(25)</td><td>Not applicable</td></tr>
<tr><td rowspan="3">Al alone or with Ti</td><td rowspan="2">Plates</td><td colspan="2" rowspan="2">A(50)</td><td>AR*(25)</td><td colspan="2">Not applicable</td></tr>
<tr><td colspan="2">N(50), CR(50)<br>TM(50)</td><td>N(50), CR(25)<br>TM(50)</td></tr>
<tr><td>Sections</td><td colspan="2">A(50)</td><td colspan="2">N(50)<br>CR(50)<br>TM(50)<br>AR*(25)</td><td>Not applicable</td></tr>
<tr><td rowspan="2">DH40</td><td rowspan="2">Killed and fine grain treated</td><td rowspan="2">Any</td><td>Plates</td><td colspan="4">N(50)<br>CR(50)<br>TM(50)</td><td>N(50)<br>TM(50)<br>QT (Each length as heat treated)</td></tr>
<tr><td>Sections</td><td colspan="4">N(50)<br>CR(50)<br>TM(50)</td><td>Not applicable</td></tr>
<tr><td>EH32<br>EH36</td><td>Killed and fine grain</td><td>Any</td><td>Plates</td><td colspan="5">N(Each piece)<br>TM(Each piece)</td></tr>
</table>

| | | | | | |
|---|---|---|---|---|---|
| | treated | | Sections | N(25)<br>TM(25)<br>AR*(15)<br>CR*(15) | Not applicable |
| **EH40** | Killed and fine grain treated | Any | Plates | N(Each piece)<br>TM(Each piece)<br>QT(Each length as heat treated) | |
| | | | Sections | N(25)<br>TM(25)<br>QT(25) | Not applicable |

**Table 3.5.2 : (Contd.)**

| **Grade** | **Deoxi-dation practice** | **Grain refining elements** | **Products** | **Condition of supply (Batch for impact tests** [(1)(2)] | |
|---|---|---|---|---|---|
| | | | | **Thickness [mm]** | |
| | | | | 10 12.5 20 25 30 35 40 50 | 100 |
| FH32<br>FH36 | Killed and fine grain treated | Any | Plates | N(Each piece)<br>TM(Each piece)<br>QT(Each length as heat treated) | Not applicable |
| | | | Section | N(25)<br>TM(25)<br>QT(25)<br>CR*(15) | Not applicable |
| FH40 | Killed and fine grain treated | Any | Plates | N(Each piece)<br>TM(Each piece)<br>QT(Each length as heat treated) | Not applicable |
| | | | Sections | N(25)<br>TM(25)<br>QT(25) | Not applicable |

Remarks

1. Condition of Supply

A - Any (Not Specified)

N - Normalised Condition

CR - Controlled Rolled Condition

TM - Thermo-Mechanical Rolling

QT - Quenched and Tempered Condition

AR* - As Rolled Condition subject to special approval of Designated Authority/Classification Society

CR* - Controlled Rolled Condition subject to special approval of Designated Authority/Classification Society.

2. Number of Impact Tests

One set of impact tests is to be taken from each batch of the "specified weight" in ( ) in tones or fraction thereof.

For Grades A32 and A36 steels charpy impact tests are not generally required provided that satisfactory results are obtained from occasional check tests selected by the Surveyor.

### 3.6 Mechanical Properties

3.6.1 For tensile test either the upper yield stress (ReH) or where ReH cannot be determined, the 0.2 percent proof stress (Rp 0.2) is to be determined and the material is considered to comply with the requirements if either value meets or exceeds the specified minimum value for yield strength (Re).

3.6.2 Results obtained from tensile tests are to comply with the appropriate requirements of Table 3.6.1.

**Table 3.6.1 : Mechanical properties for higher strength steels**

| Grade | Yield stren-gth ReH [N/mm$^2$] min. | Tensile strength Rm [N/mm$^2$] | Elon-gation 5.65 $\sqrt{S_o}$ A5 (%) | Impact Test | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Test Temp. °C | Average impact energy (J) min. | | | | | |
| | | | | | t ≤ 50 mm | | 50 < t ≤ 70 mm | | 70 < t ≤ 100 mm | |
| | | | | | Long (2) | Trans (2) | Long (2) | Trans (2) | Long (2) | Trans (2) |
| AH32 | 315 | 440/570 | 22(1) | 0 | 31(3) | 23(3) | 38 | 26 | 46 | 31 |
| DH32 | | | | -20 | 31 | 22 | 38 | 26 | 46 | 31 |
| EH32 | | | | -40 | 31 | 22 | 38 | 26 | 46 | 31 |
| FH32 | | | | -60 | 31 | 22 | 38 | 26 | 46 | 31 |
| AH36 | 355 | 490/630 | 21(1) | 0 | 34(3) | 24(3) | 41 | 27 | 50 | 34 |
| DH36 | | | | -20 | 34 | 24 | 41 | 27 | 50 | 34 |
| EH36 | | | | -40 | 34 | 24 | 41 | 27 | 50 | 34 |
| FH36 | | | | -60 | 34 | 24 | 41 | 27 | 50 | 34 |
| AH40 | 390 | 510/660 | 20(1) | 0 | 39 | 27 | 46 | 31 | 55 | 37 |
| DH40 | | | | -20 | 39 | 27 | 46 | 31 | 55 | 37 |
| EH40 | | | | -40 | 39 | 27 | 46 | 31 | 55 | 37 |
| FH40 | | | | -60 | 39 | 27 | 46 | 31 | 55 | 37 |

t = thickness [mm]

NOTES:

1) For full thickness flat tensile test specimens with a width of 25 [mm] and a gauge length of 200 [mm] the elongation [%] is to comply with the following minimum values:

| Grade | Thickness [mm] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | ≤ 5 | > 5 ≤ 10 | > 10 ≤ 15 | > 15 ≤ 20 | > 20 ≤ 25 | > 25 ≤ 30 | > 30 ≤ 40 | > 40 ≤ 50 |
| AH32, DH32, EH32 & FH32 | 14 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| AH36, DH36, EH36 & FH36 | 13 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| AH40, DH40, EH40 & FH40 | 12 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |

2) See 3.6.3.

3) For Grades AH32 and AH36 steels a relaxation in the number of impact tests for acceptance purposes may be permitted by special agreement with Designated Authority/Classification Society provided that satisfactory results are obtained from occasional check tests.

**Table 3.6.2 : Conditions of supply, grade and mechanical properties for EH47 steel plates**

| Supply Condition | Grade | Mechanical Properties | | | Impact Test | | | |
|---|---|---|---|---|---|---|---|---|
| | | Yield Strength [N/mm$^2$]min | Tensile Strength [N/mm$^2$] | Elongation (%) min. | Test Temp. ($^o$C) | Average Impact Energy [J] min. | | |
| | | | | | | 50<t≤ 70 | 70<t≤85 | 85<t≤ 100 |
| TMCP | EH 47 | 460 | 570/720 | 17 | -40$^o$C | 53 | 64 | 75 |

Note : t: Thickness [mm]

1). The additional requirements for EH47 steel with brittle crack arrest properties are specified in Section 10.

c)

3.6.3 Minimum average energy values are specified for Charpy V-notch impact test specimens taken in either the longitudinal or transverse directions. Generally, only longitudinal test specimens need be prepared and tested except for special applications where transverse test specimens may be required. Transverse test results are to be guaranteed by the manufacturer. The tabulated values are for standard specimens 10 [mm] x 10 [mm]. For plate thicknesses lower than 10 [mm], sub-size specimens may be used with reduced requirements as follows :

Specimen 10 x 7.5 [mm] : 5/6 of tabulated energy

Specimen 10 x 5 [mm] : 2/3 of tabulated energy.

3.6.4 For impact tests, the average value obtained from one set of three impact tests is to comply with the requirements given in Table 3.6.1. One individual value may be less than the required average value provided that it is not less than 70 per cent of this average value. See also Chapter 1.

3.6.5 Generally, impact tests are not required when the nominal plate thickness is less than 6 [mm].

**3.7 Surface Quality**

3.7.1 Requirements of 2.7 are applicable.

**3.8 Internal Soundness**

3.8.1 Requirements of 2.8 are applicable.

**3.9 Tolerances**

3.9.1 Requirements of 2.9 are applicable.

**3.10 Identification of Materials**

3.10.1 Requirements of 2.10 are applicable

**3.11 Testing and Inspection**

3.10.1 Requirements of 2.11 are applicable

**3.12 Test Material**

3.12.1 Requirements of 2.12 are applicable

**3.13 Mechanical tests specimens**

3.13.1 Tensile Test Specimens. The dimensions of the tensile test specimens are to be in accordance Ch.2. Generally for plates, wide flats and sections flat test specimens of full product thickness are to be used. Round test specimens may be used when the product thickness exceeds 40 [mm] or for bards and other similar products. Alternatively for small sizes of bars, etc. test specimens may consist of a suitable length of the full cross section of the product.

3.13.2 Impact Test Specimens. The impact test specimens are to be of the Charpy V-notch type cut with their edge within 2 [mm] from the “as rolled” surface with their longitudinal axes either parallel (indicated “Long” in Table 3.6.1) or transverse (indicated "Trans" in Table 3.6.1) to

the final direction of rolling of the material. The notch is to be cut in a face of the test specimen which was originally perpendicular to the rolled surface. The position of the notch is not to be nearer than 25 [mm] to a flame cut or sheared edge (see also 3.6.3). Where the product thickness exceeds 40 [mm], the impact test specimens are to be taken with their longitudinal axis at a quarter thickness position.

**3.14 Number of Test Specimens**

3.14.1 Number of Tensile Tests. For each batch presented, except where specially agreed by Designated Authority/Classification Society, one tensile test is to be made from one piece unless the weight of finished material is greater than 50 tonnes

in which case one extra test piece is to be made from a different piece from each 50 tonnes or fraction thereof. Additional tests are to be made for every variation of 10 [mm] in thickness of plate or diameter of products from the same cast. For sections, the thickness to be considered is the thickness of the product at the point at which samples are taken for mechanical tests.

3.14.2 Number of Impact Tests (except for Grades EH32, EH36, EH40, EH47, FH32, FH36 and FH40):

i) Except where otherwise specified or specially agreed by Designated Authority/Classification Society, for each batch presented, at least one set of three Charpy V-notch impact test specimen is to be made from one piece unless the weight of finished material is greater than 50 tonnes, in which case one extra set of three test specimens is to be made from a different piece from each 50 tonnes or fraction thereof. When steel plates over 50 [mm] in thickness is supplied in the controlled rolled condition, the frequency of impact test is to be made from a different piece from each 25 tonnes or fraction therof.

ii) For steel plates of Grades AH40 and DH40 with thickness over 50 [mm] in normalized or TM condition, one set of impact test specimens is to be taken from each batch of 50 tonnes or fraction thereof. For those in QT condition, one set of impact test specimens is to be taken from each length as heat treated.

iii) When, subject to special approval of Designated Authority/Classification Society, material is supplied in the as rolled condition, the frequency of impact tests is to be increased to one set from each batch of 25 tonnes or fraction thereof.

iv) The piece selected for the preparation of test specimens is to be the thickest in each batch.

3.14.3 Number of Impact Tests (Grades EH32, EH36, EH40, FH32, FH36 and FH40):

i) For plates supplied in the normalized or TM condition one set of three Charpy V-notch impact test specimens is to be taken from each piece. For quenched and tempered steel plates one set of impact test specimens is to be taken from each length as heat treated.

ii) For sections one set of impact tests is to be taken from each batch of 25 tonnes or fraction thereof.

iii) When, subject to special approval of Designated Authority/Classification Society, sections other than Grades EH40 and FH40 are supplied in the as-rolled or controlled rolled condition, one set of impact tests is to be taken from each batch of 15 tonnes or fraction thereof.

iv) For (ii) and (iii) above the piece selected for the preparation of test specimens is to be the thickest in each batch.

### 3.16 Retest Procedures

3.16.1 Retest procedures are to be as per the requirements provided in Chapter 1.

## Section 4

## High Strength Steels for Welded Structures

### 4.1 General

4.1.1 These requirements apply to hot-rolled, fine-grain, weldable high strength structural steels, intended for use in marine and offshore structural applications. These requirements do not apply to steels intended for hull structure of commercial ships whose requirements are specified in previous sections.

4.1.2 The steel covered by the scope of these requirements are specified in yield strength levels of 420, 460, 500, 550, 620, 690,890 and 960 [N/mm$^2$]. For each yield strength level grades AH, DH, EH and FH are specified, based on the impact test temperature, except for yield strength level of 890 and 960 [N/mm$^2$] for which grade F is not applicable. The full list of grades are:

| | | | |
|---|---|---|---|
| **AH420** | **DH420** | **EH420** | **FH420** |
| **AH460** | **DH460** | **EH460** | **FH460** |
| **AH500** | **DH500** | **EH500** | **FH500** |
| **AH550** | **DH550** | **EH550** | **FH550** |
| **AH620** | **DH620** | **EH620** | **FH620** |
| **AH690** | **DH690** | **EH690** | **FH690** |
| **AH890** | **DH890** | **EH890** | |
| **AH960** | **DH960** | **EH960** | |

4.1.3 Steels covered by the scope may be delivered in Normalized (N)/Normalized rolled (NR); Thermo-mechanical controlled rolled (TM) or Quenched and Tempered (QT) condition.

Note: TM is a generic delivery condition that may not include accelerated cooling, and may or may not include direct quenching followed by tempering after TM-rolling.

4.1.4 Product forms include plates, wide flats, sections bars and seamless tubulars.

4.1.5 Steels with a thickness beyond the maximum thicknesses as given in Table 4.5.3 may be approved at the discretion of the Designated Authority/ Classification Society.

4.1.6 Steels differing in chemical composition, deoxidation practice, delivery condition and mechanical properties may be accepted, subject to the special approval of the Designated Authority/Classification Society. Such steels are to be given a special designation.

**4.2 Approval**

4.2.1 All steels are to be manufactured at steel works which have been approved by Designated Authority/Classification Society for the type and grade of steel which is being supplied. Refer Chapter 1, Section 1, Cl. 1.3.2.

4.2.2 It is the steelmaker's responsibility to assure that effective quality, process and production controls during manufacturing are adhered to within the manufacturing specification. The manufacturing specification is to be submitted to Designated Authority/Classification Society at the time of initial approval.

4.2.3 Where non-conformities arise, the manufacturer is to identify the root cause and establish countermeasures to prevent its recurrence. The non-conformities and the countermeasures are to be documented and reported to Designated Authority/Classification Society.

4.2.4 When the semi-finished products were not manufactured by the approved manufacturer of the finish rolled and heat treated products, the manufacturer of the semi-finished product is also to be subject to approval by Designated Authority/Classification Society.

Note 1: The attention of the users must be drawn to the fact that when fatigue loading is present, the effective fatigue strength of a welded joint of high strength steel may not be greater than that of a welded joint in normal strength steels.

Note 2: Before subjecting steels produced by thermos-mechanical rolling or quenched and tempered after rolling to further heating for forming or stress relieving, or using high heat-input welding, special consideration must be given to the possibility of a consequent reduction in mechanical properties

**4.3 Method of manufacture**

4.3.1 Steel making process

4.3.1.1 The steel is to be manufactured by the basic oxygen, basic electric arc furnace or by processes specially approved by Designated Authority/ Classification Society.

4.3.1.2 Vacuum degassing is to be used for any of the following:

a) all steels with enhanced through-thickness properties, and

b) all steels of grade H690, H890 and H960.

4.3.2 Deoxidation

4.3.2.1 The steel shall be fully killed .

4.3.3 Grain size

4.3.3.1 The steel is to be fine grain treated, and is to have a fine grain structure. The fine grain practice is to be as detailed in the manufacturing specification.

Note: A fine grain structure has an equivalent index ≥ 6 determined by micrographic examination in accordance with ISO 643 or alternative test method.

4.3.4 Nitrogen control

4.3.4.1 The steels are to contain nitrogen binding elements as detailed in the manufacturing specification. Also see note 4 in Table 4.4.1.

**4.4 Chemical composition**

4.4.1 The chemical composition is to be determined by the steel maker, in an adequately equipped competently staffed laboratory. The method of sampling is to follow that carried out for the initial approval tests, either from the ladle, the tundish or the mould in the case of continuous casting. The aim analysis is to be in accordance with the manufacturing specification. All the elements listed in the Table 4.4.1 are to be reported.

4.4.2 Elements used for alloying, nitrogen binding, and fine grain treatment, and as well as the residual elements are to be as detailed in the manufacturing specification, e.g. When boron is deliberately added for enhancement of hardenability of the steels, the maximum content of the boron content is not to be higher than 0.005%; and the analysis result is to be reported.

4.4.3 The carbon equivalent value is to be calculated from the ladle analysis. Maximum values are specified in Table 4.4.2.

a) For all steel grades the following formula of IIW may be used:

$$Ceq = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} \ (\%)$$

b) For steel grades H460 and higher, CET may be used instead of Ceq at the discretion of the manufacturer, and is to be calculated according to the following formula:

$$CET = C + \frac{(Mn + Mo)}{10} + \frac{(Cr + Cu)}{20} + \frac{Ni}{40} \ (\%)$$

Note: The CET is included in the standard EN 10011-2:2001 used as one of the parameters for pre-heating temperature determination which is necessary for avoiding cold cracking.

c) For TM and QT steels with carbon content not more than 0.12%, the cold cracking susceptibility *P*cm for evaluating weldability may be used instead of carbon equivalent of *Ceq* or *CET* at manufacturer's discretion and is to be calculated using the following formula:

$$P_{cm} = C + \frac{Si}{30} + \frac{Mn}{20} + \frac{Cu}{20} + \frac{Ni}{60} + \frac{Cr}{20} + \frac{Mo}{15} + \frac{V}{10} + 5B$$

**Table 4.4.1 : Chemical composition**

| **Delivery condition**[1)] | **N/NR** | | **TM** | | **QT** | |
|---|---|---|---|---|---|---|
| **Steel grade** / **Chemical Composition**[2)] | **AH420<br>DH420<br>AH460<br>DH460** | **EH420<br>EH460** | **AH420<br>DH420<br>AH460<br>DH460<br>AH500<br>DH500<br>AH550<br>DH550<br>AH620<br>DH620<br>AH690<br>DH690<br>AH890** | **EH420<br>FH420<br>EH460<br>FH460<br>EH500<br>FH500<br>EH550<br>FH550<br>EH620<br>FH620<br>EH690<br>FH690<br>DH890<br>EH890** | **AH420<br>DH420<br>AH460<br>DH460<br>AH500<br>DH500<br>AH550<br>DH550<br>AH620<br>DH620<br>AH690<br>DH690<br>AH890<br>AH960** | **EH420<br>FH420<br>EH460<br>FH460<br>EH500<br>FH500<br>EH550<br>FH550<br>EH620<br>FH620<br>EH690<br>FH690<br>DH890<br>EH890<br>DH960<br>EH960** |
| Carbon % max | 0.20 | 0.18 | 0.16 | 0.14 | 0.18 | |
| Manganese % | 1.0~1.70 | | 1.0~1.70 | | 1.70 | |
| Silicon % max | 0.60 | | 0.60 | | 0.80 | |
| Phosphorus % max[3)] | 0.030 | 0.025 | 0.025 | 0.020 | 0.025 | 0.020 |
| Sulphur % max[3)] | 0.025 | 0.020 | 0.015 | 0.010 | 0.015 | 0.010 |
| $Aluminium_{total}$ % min[4)] | 0.02 | | 0.02 | | 0.018 | |
| Niobium % max[5)] | 0.05 | | 0.05 | | 0.06 | |
| Vanadium % max[5)] | 0.20 | | 0.12 | | 0.12 | |
| Titanium % max[5)] | 0.05 | | 0.05 | | 0.05 | |
| Nickel % max[6)] | 0.80 | | 2.00[6)] | | 2.00[6)] | |
| Copper % max | 0.55 | | 0.55 | | 0.50 | |
| Chromium % max[5)] | 0.30 | | 0.50 | | 1.50 | |
| Molybdenum % max[5)] | 0.10 | | 0.50 | | 0.70 | |
| Nitrogen % max | 0.025 | | 0.025 | | 0.015 | |
| Oxygen ppm max[7)] | Not applicable | | Not applicable | 50 | Not applicable | 30 |

**Note 1** See section 4.5 for definition of delivery conditions

**Note 2** The chemical composition is to be determined by ladle analysis and is to meet the approved manufacturing specification at the time of approval.

**Note 3** For sections the P and S content can be 0.005 % higher than the value specified in the table.

Note 4 The total aluminium to nitrogen ratio shall be a minimum of 2:1. When other nitrogen binding elements are used, the minimum Al value and Al/N ratio do not apply.

**Note 5** Total Nb+V+Ti $\leq$ 0.26 % and Mo+Cr $\leq$0.65%, not applicable for QT steels.

**Note 6** Higher Ni content may be approved at the discretion of Designated Authority/Classification Society.

**Note 7** The requirement on maximum Oxygen content is only applicable to DH890; EH890; DH960 and EH960.

**Table 4.4.2 : Maximum Ceq, *CET* and *P*cm values**

| Steel grade & delivery condition | Carbon Equivalent (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *Ceq* | | | | | | *CET* | *P*cm |
| | Plates | | | Sections | Bars | Tubulars | all | all |
| | t≤50 (mm) | 50<t≤100 (mm) | 100<t≤250 (mm) | t≤50 (mm) | t≤250 or d≤250 (mm) | t≤65 (mm) | all | all |
| H420N/NR | 0.46 | 0.48 | 0.52 | 0.47 | 0.53 | 0.47 | N.A | N.A |
| H420TM | 0.43 | 0.45 | 0.47 | 0.44 | N.A | N.A | N.A | N.A |
| H420QT | 0.45 | 0.47 | 0.49 | N.A | N.A | 0.46 | N.A | N.A |
| H460N/NR | 0.50 | 0.52 | 0.54 | 0.51 | 0.55 | 0.51 | 0.25 | N.A |
| H460TM | 0.45 | 0.47 | 0.48 | 0.46 | N.A | N.A | 0.30 | 0.23 |
| H460QT | 0.47 | 0.48 | 0.50 | N.A | N.A | 0.48 | 0.32 | 0.24 |
| H500TM | 0.46 | 0.48 | 0.50 | N.A | N.A | N.A | 0.32 | 0.24 |
| H500QT | 0.48 | 0.50 | 0.54 | N.A | N.A | 0.50 | 0.34 | 0.25 |
| H550TM | 0.48 | 0.50 | 0.54 | N.A | N.A | N.A | 0.34 | 0.25 |
| H550QT | 0.56 | 0.60 | 0.64 | N.A | N.A | 0.56 | 0.36 | 0.28 |
| H620TM | 0.50 | 0.52 | N.A | N.A | N.A | N.A | 0.34 | 0.26 |
| H620QT | 0.56 | 0.60 | 0.64 | N.A | N.A | 0.58 | 0.38 | 0.30 |
| H690TM | 0.56 | N.A | N.A | N.A | N.A | N.A | 0.36 | 0.30 |
| H690QT | 0.64 | 0.66 | 0.70 | N.A | N.A | 0.68 | 0.40 | 0.33 |
| H890TM | 0.60 | N.A | N.A | N.A | N.A | N.A | 0.38 | 0.28 |
| H890QT | 0.68 | 0.75 | N.A | N.A | N.A | N.A | 0.40 | N.A |
| H960QT | 0.75 | N.A | N.A | N.A | N.A | N.A | 0.40 | N.A |
| **Note:** N.A = Not applicable | | | | | | | | |

**4.5 Delivery Condition - Rolling Process and Heat Treatment**

4.5.1 Steel is to be delivered in accordance with the processes approved by Designated Authority/ Classification Society. These processes include:

- Normalized (N)/Normalized rolled (NR)
- Thermo-mechanical controlled rolled (TM)/with Accelerated cooling (TM+AcC)/with direct quenching followed by tempering (TM+DQ), or
- Quenched and Tempered condition (QT)

The definition of these delivery conditions are defined in previous sections.

Note: Direct quenching after hot-rolling followed by tempering is considered equivalent to conventional quenching and tempering.

4.5.2 Rolling reduction ratio

4.5.2.1 The rolling reduction ratio of slab, billet, bloom or ingot is not to be less than 3:1 unless agreed at the time of approval.

4.5.3 Thickness limits for approval

4.5.3.1 The maximum thickness of slab, billet or bloom from the continuous casting process is to be at the manufacturer's discretion.

4.5.3.2 Maximum thickness of plates, sections, bars and tubulars over which a specific delivery condition is applicable are shown in Table 4.5.3.

**Table 4.5.3 : Maximum thickness limits**

| Delivery condition | Maximum thickness (mm) | | | |
|---|---|---|---|---|
| | **Plates** | **Sections** | **Bars** | **Tubulars** |
| N | 250[2)] | 50 | 250 | 65 |
| NR | 150 | 1) | | |
| TM | 150 | 50 | Not applicable | Not applicable |
| QT | 150[2)] | 50 | Not applicable | 50 |

Note 1 The maximum thickness limits of sections, bars and tubulars produced by NR process route are less than those manufactured by N route, and are to be at the discretion of Designated Authority/Classification Society.

Note 2 Approval for N steels with thickness larger than 250 [mm] and QT steels with thickness larger than 150 [mm] is subject to the special consideration of Designated Authority/Classification Society.

## 4.6 Mechanical Properties

4.6.1 Test specimens and test procedures for mechanical properties are in accordance with Chapter 2 and Section 3 of this chapter.

4.6.2 Tensile test

4.6.2.1 Test specimens are to be cut with their longitudinal axes transverse to the final direction of rolling, except in the case of sections, bars, tubulars and rolled flats with a finished width of 600 [mm] or less, where the tensile specimens may be taken in the longitudinal direction.

4.6.2.2 Full thickness flat tensile specimens are to be prepared. The specimens are to be prepared in such a manner as to maintain the rolling scale at least at one side. When the capacity of the test machine is exceeded by the use of a full thickness specimen, sub-sized flat tensile specimens representing either the full thickness or half of the product thickness retaining one rolled surface are to be used. Alternatively, machined round test specimens may be used. The specimens are to be located at a position lying at a distance of t/4 from the surface and additionally at t/2 for thickness above 100 [mm] or as near as possible to these positions.

4.6.2.3 The results of the tests are to comply with the appropriate requirements of Table 4.6.2.3. In the case of product forms other than plates and wide flats where longitudinal tests are agreed, the elongation values are to be 2 percentage units above those transverse requirements as listed in Table 4.6.2.3.

**Table 4.6.2.3 : Tensile properties at ambient temperature for all steel grades**

| Mechanical properties / Steel grade & delivery condition | | Minimum yield strength $ReH$[1)] (N/mm$^2$) Nominal thickness (mm)[4)] | | | Ultimate tensile strength $Rm$ (N/mm$^2$) Nominal thickness (mm)[4)] | | Minimum Percentage elongation After fracture (%) $L_0=5.65\sqrt{S_0}$ [2)] | | Charpy V-notch impact test Test temp (°C) | Charpy V-notch impact test Minimum (Joules) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ≥3 ≤50 | >50 ≤ 100 | >100 ≤250 | ≥3 ≤100 | >100 ≤250 | T | L[3)] | | T | L |
| H420N/NR<br>H420TM<br>H420QT | A<br>D<br>E<br>F | 420 | 390 | 365 | 520~680 | 470~650 | 19 | 21 | 0<br>-20<br>-40<br>-60 | 28 | 42 |
| H460N/NR<br>H460TM<br>H460QT | A<br>D<br>E<br>F | 460 | 430 | 390 | 540~720 | 500~710 | 17 | 19 | 0<br>-20<br>-40<br>-60 | 31 | 46 |
| H500TM<br>H500QT | A | 500 | 480 | 440 | 590~770 | 540~720 | 17 | 19 | 0 | 33 | 50 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | D<br>E<br>F | | | | | | | | -20<br>-40<br>-60 | | |
| H550TM<br>H550QT | A<br>D<br>E<br>F | 550 | 530 | 490 | 640~820 | 590~770 | 16 | 18 | 0<br>-20<br>-40<br>-60 | 37 | 55 |
| H620TM<br>H620QT | A<br>D<br>E<br>F | 620 | 580 | 560 | 700~890 | 650~830 | 15 | 17 | 0<br>-20<br>-40<br>-60 | 41 | 62 |
| H690TM<br>H690QT | A<br>D<br>E<br>F | 690 | 650 | 630 | 770~940 | 710~900 | 14 | 16 | 0<br>-20<br>-40<br>-60 | 46 | 69 |
| H890TM<br>H890QT | AD<br>E | 890 | 830 | Not applicable | 940~1100 | Not applicable | 11 | 13 | 0<br>-20<br>-40 | 46 | 69 |
| H960QT | ADE | 960 | Not applicable | Not applicable | 980~1150 | Not applicable | 10 | 12 | 0<br>-20<br>-40 | 46 | 69 |

**Note 1** For tensile test either the upper yield stress ($R_{eH}$) or where $R_{eH}$ cannot be determined, the 0.2 percent proof st*re*ss ($Rp0.2$) is to be determined and the material is considered to comply with the requirement if either value meets or exceeds the specified minimum value of yield strength.

**Note 2** For full thickness flat test specimens with a width of 25 [mm] and a gauge length of 200 [mm] the elongation is to comply with the minimum values shown in Table 4.6.2.4.

**Note 3** In the case that the tensile specimen is parallel to the final rolling direction, the test result shall comply with the requirement of elongation for longitudinal (L) direction.

**Note 4** For plates and sections for applications, such as racks in offshore platforms etc, where the design requires that tensile properties are maintained through the thickness, a decrease in the minimum specified tensile properties is not permitted with an increase in the thickness.

**Table 4.6.2.4 : Elongation minimum values for a width of 25 [mm] and a 200 [mm] gauge length[1)]**

| Strength Grade | Thickness [mm] | | | | | | |
|---|---|---|---|---|---|---|---|
| | **≤ 10** | **> 10 ≤ 15** | **> 15 ≤ 20** | **> 20 ≤ 25** | **> 25 ≤ 40** | **> 40 ≤ 50** | **> 50 ≤ 70** |
| H420 | 11 | 13 | 14 | 15 | 16 | 17 | 18 |
| H460 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| H500 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| H550 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| H620 | 9 | 11 | 12 | 12 | 13 | 14 | 15 |
| H690 | 9[2)] | 10[2)] | 11[2)] | 11 | 12 | 13 | 14 |

**Note 1** The tabulated elongation minimum values are the requirements for testing specimen in transverse direction. H890 and 960 specimens and specimens which are not included in this table is to be proportional

specimens with a gauge length of $L_0 = 5.65\sqrt{S_0}$.

**Note 2** For H690 plates with thickness ≤ 20 [mm], round specimen in accordance with Chapter 2 may be used instead of the flat tensile specimen. The minimum elongation for testing specimen in transverse direction is 14%.

**4.6.3 Impact test**

4.6.3.1 The Charpy V-notch impact test specimens for plates and wide flats over 600 [mm] in width are to be taken with their axes transverse to the final rolling direction and the results should comply with the appropriate requirements for transverse direction of Table 4.6.2.3. For other product forms, the impact tests are to be in the longitudinal direction, the results of the tests are to comply with the appropriate requirements for longitudinal direction of Table 4.6.2.3.

4.6.3.2 Sub-surface test specimens will be taken in such a way that one side is not further away than 2 [mm] from a rolled surface, however, for material with a thickness in excess of 50 [mm], impact tests are to be taken at the quarter thickness (t/4) location and mid-thickness (t/2).

4.6.3.3 Impact test for a nominal thickness less than 6 [mm] are normally not required.

4.6.4 Test frequency

4.6.4.1 Tensile test sample is to be randomly selected from each batch, as defined in section 3, that is to be less than or equal to 25 tonnes, and to be from the same cast, in the same delivery condition and of the same thickness.

4.6.4.2 Impact test

a) For steels plates in N/NR or TM condition test sample is to be taken from each piece.

b) For steels in QT condition test sample is to be taken from each individually heat treated part thereof.

c) For sections, bars and tubulars, test sample is to be taken from each batch of 25 tonnes or fraction thereof.

Note 1: If the mass of the finished material is greater than 25 tonnes, one set of tests from each 25 tonnes and/or fraction thereof is required. (e.g. for consignment of 60 tonnes would require 3 plates to be tested).

Note 2: For continuous heat treated product special consideration may be given to the number and location of test specimens required by the manufacturer to be agreed by Designated Authority/Classification Society.

4.6.5 Traceability

4.6.5.1 Traceability of test material, specimen sampling and test procedures including test equipment with respect to mechanical properties testing, is to be in accordance with section 3.

4.6.6 Re-test procedures

4.6.6.1 Re-test procedures for tensile tests and Charpy impact tests are to be in accordance with Chapter 2.

4.6.7 Through thickness tensile test

4.6.7.1 For steels designated with improved through thickness properties, through thickness tensile tests are to be performed in accordance with Section 8.

4.6.7.2 Subject to the discretion of Designated Authority/Classification Society, through thickness tensile strength may be required to be not less than 80% of the specified minimum tensile strength.

**4.7 Tolerances**

4.7.1 Unless otherwise agreed or specially required, the thickness tolerances in Sec 1, 1.4 are applicable.

**4.8 Surface Quality**

4.8.1 All materials are to be free from cracks, injurious surface flaws, injurious laminations and similar defects.

4.8.2 The surface quality inspection method is to be in accordance with recognised national or international standards agreed between purchaser and manufacturer.

a) Welding repair procedures and the method for reporting repairs are to be approved by the Designated Authority/ Classification Society.

b) Where repair by grinding is carried out then the remaining plate thickness below the ground area must be within the allowable under thickness tolerance.

4.8.3 Surface finish requirement are to be in accordance with the relevant requirements in Section 3.

4.8.4 Surface inspection is the responsibility of the manufacturer. The acceptance by Designated Authority/Classification Society's Surveyor of material later found to be defective shall not absolve the manufacturer of this responsibility.

**4.9 Internal Soundness**

4.9.1 Verification of internal soundness is the responsibility of the manufacturer. The acceptance by the Designated Authority/Classification Society's Surveyor shall not absolve the manufacturer of this responsibility.

4.9.2 Ultrasonic examination

4.9.2.1 If required by the Designated Authority/Classification Society, ultrasonic examination should be carried out in accordance with Section 2 for the requirement of internal soundness, and is to be performed in accordance with an approved standard.

**4.10 Stress relieving heat treatment and other heat treatments**

4.10.1 Steels approved with respect to Heat Treatment are suitable for stress relieving heat treatment such as post-weld heat treatment and stress relieving heat treatment after cold forming for the purpose of reducing the risk of brittle fracture, increasing the fatigue lifetime and dimensional stability for machining.

Note: Products can be susceptible to deterioration in mechanical strength and toughness if they are subjected to incorrect post-weld heat treatment procedures or other processes involving heating such as flame straightening, rerolling, etc. where the heating temperature and the holding time exceed the limits given by the manufacturer.

**4.11 Facilities for Inspection**

4.11.1 Testing is to be carried out under the witness of the Surveyor, or an authorised deputy, in order to verify whether the test results meet the specified requirements.

4.11.2 The manufacturer is to afford the Surveyor all necessary facilities and access to all relevant parts of the steel works to enable him to verify the approved process is adhered to, for the selection of test materials, and the witnessing of tests, as required by this Section. Also for verifying the accuracy of the testing, calibration of inspection equipment and traceability of materials.

**4.12 Identification of Materials**

4.12.1 The manufacturer is to adopt a system for the identification of ingots, slabs, billet or bloom and finished products, which will enable the material to be traced to its original cast. The Surveyor is to be given full facilities for so tracing the material when required.

**4.13 Branding**

4.13.1 Each finished piece is to be clearly marked by the manufacturer with the following particulars:

a) Designated Authority/Classification Society's brand mark

b) Unified identification mark for the grade of steel (e.g. EH620)

c) Name or initials to identify the steelworks

d) Cast number/Heat number, plate number or equivalent identification mark

e) Delivery condition (N/NR, TM/TM+AcC/TM+DQ or Q&T)

The entire markings are to be encircled with paint or otherwise marked so as to be easily recognised. Steels which have been specially approved by Designated Authority/Classification Society and which differ from these requirements (see 4.1.6) are to have the letter "S" after the identification mark (e.g. EH620S)

**4.14 Documentation of Inspection Tests**

4.14.1 The Surveyor is to be supplied with two copies, of the test certificates or shipping statements for all accepted materials. In addition

to the description, dimensions, etc., of the material, the following particulars are to be included:

a) Purchaser's order number

b) Identification of the cast and piece

c) Manufacturer's identification

d) Identification of the grade of steel

e) Chemical analysis, *Ceq*, *CET* or *P*cm value

f) Delivery condition with heat treatment temperatures

g) Mechanical properties test results, including traceable test identification

h) Surface quality and inspection results

i) UT result, where applicable

4.14.2 Before the test certificates are signed by the Surveyor, the steelmaker is required to provide a written declaration stating that the material has been made by an approved process, and that it has been subjected to and has withstood satisfactorily the required tests in the presence of the Surveyor, or an authorised deputy. The following form of declaration will be accepted if stamped or printed on each test certificate with the name of the steelworks and signed by an authorised representative of the manufacturer:

"We hereby certify that the material has been made by an approved process and has been satisfactorily tested in accordance with the requirements of Designated Authority/Classification Society".

## Section 5

## Steel for Low Temperature Service

### 5.1 General

5.1.1 This section gives specific requirements for carbon-manganese and nickel alloy steels with toughness properties at low temperatures and intended for use in the construction of cargo tanks and process pressure vessels for liquefied gases.

5.1.2 The requirements of this section are also applicable for other types of pressure vessels where the use of steels with guaranteed impact properties at low temperature is required.

5.1.3 Provision is made for plates and sections up to 40 [mm] thick.

5.1.4 Steel differing in chemical composition, condition of supply or mechanical properties may be accepted, subject to special agreement by Designated Authority/Classification Society.

### 5.2 Deoxidation and chemical composition

5.2.1 All steels are to be in the fully killed and fine grain refined condition.

5.2.2 The chemical composition of carbon-manganese steels are to comply with the appropriate requirements of grades AH, DH, EH

and FH strength levels 32, 36 and 40 (See Table 3.2.1). However, these grades are to be designated as L T -AH, L T -DH, L T -EH and L T -FH respectively for the uses defined in 5.1.1.

5.2.3 The chemical compositions of nickel alloy steels are to comply with the appropriate requirements of Table 5.2.1.

**Table 5.2.1 : Chemical composition of nickel alloy steels**

| Elements | 1.5 Ni | 3.5 Ni | 5 Ni | 9 Ni |
|---|---|---|---|---|
| C max. | 0.18 | 0.15 | 0.12 | 0.10 |
| Si | 0.10 - 0.35 | 0.10 - 0.35 | 0.10 - 0.35 | 0.10 - 0.35 |
| Mn | 0.30 - 1.50 | 0.30 - 0.90 | 0.30 - 0.90 | 0.30 - 0.90 |
| Ni | 1.30 - 1.70 | 3.20 - 3.80 | 4.70 - 5.30 | 8.50 - 10.0 |
| P max. | 0.025 | 0.025 | 0.025 | 0.025 |
| S max. | 0.020 | 0.020 | 0.020 | 0.020 |
| Al min. (acid soluble)[1)] | 0.015 | 0.015 | 0.015 | 0.015 |
| Residual elements | | | | |
| Cr max. | 0.25 | 0.25 | 0.25 | 0.25 |
| Cu max. | 0.35 | 0.35 | 0.35 | 0.35 |
| Mo max. | 0.08 | 0.08 | 0.08 | 0.08 |
| Total of residual elements max. | 0.60 | 0.60 | 0.60 | 0.60 |

1) The total aluminium content may be determined by other methods instead of the acid soluble method. In such cases the total aluminium content is to be not less than 0.020 percent.

### 5.3 Heat treatment

5.3.1 All materials are to be supplied in a condition complying with Table 5.3.1.

**Table 5.3.1 : Conditions of supply**

| Grade | Plates | Sections and Bars |
|---|---|---|
| LT-AH | N, TMCP | Any |
| LT-DH | N, TMCP | Any |
| LT-EH | $N^2$, TMCP, QT | N, TMCP |
| LT-EH | $N^2$, TMCP, QT | N, TMCP |

| | |
|---|---|
| 1.5 Ni<br>3.5 Ni<br>5 Ni | N[2], QT, normalized and tempered<br>N[2], QT, normalized and tempered<br>N[2], QT, normalized and tempered |
| 9 Ni | QT, Double normalized and tempered |

1 N = Normalized

TMCP = Thermo-mechanically controlled process

QT = Quenched and tempered

2 The term "Normalized" does not include normalized rolling.

**5.4 Mechanical tests**

5.4.1 Test pieces for tensile testing of plates are to be cut with their principal axes transverse to the final direction of rolling.

5.4.2 For each batch of plate presented, one tensile test is to be made from one end of each piece unless the mass and length of the piece exceeds 5 tonnes and 15 m in which case test pieces are to be taken from both ends of each piece.

5.4.3 Sections and bars are to be presented for acceptance test in batches containing not more than 50 lengths, as supplied. The material in each batch is to be of the same section size, from the same cast and in the same condition of supply. One tensile test specimen is to be taken from material representative of each batch, except that additional tests are to be taken when the mass of a batch exceeds 10 tonnes.

5.4.4 One set of three Charpy V-notch impact test specimens are to be taken for each tensile test specimen required. For plates, these are to be cut with their principal axis perpendicular to the final direction of rolling and for sections. these are to be taken longitudinally.

5.4.5 The results of all tensile tests are to comply with appropriate requirements given in Table 5.4.1. The ratio between the yield stress and the tensile strength is not to exceed 0.9 for normalized and TMCP steels and 0.94 for Q & T steels.

5.4.6 The average energy value from each set of three impact tests are to comply with appropriate requirements given in Table 5.4.1.

5.4.7 When standard subsidiary impact specimens are necessary (See Sec. 2).

5.4.8 When steel with improved through thickness properties is required or specified in the order, the materials are to be tested as detailed in Sec. 8.

**Table 5.4.1 : Mechanical properties for acceptance purposes**

| **Grade of Steel** | | **Yield stress [N/mm$^2$] min.** | **Tensile strength [N/mm$^2$]** | **Elongation on $5.65\sqrt{S_o}$ % min.** | **Charpy V-notch impact test** | |
|---|---|---|---|---|---|---|
| | | | | | **Test temp.°C** | **Impact Energy min.** |
| LT-AH | 32 | 315 | 440 - 590 | 22 | 0 | Plates transverse tests Average energy 27 J Sections and bars longitudinal tests Average energy 41 J |
| | 36 | 355 | 490 - 620 | 21 | | |
| | 40 | 390 | 510 - 650 | 20 | | |
| LT-DH | 32 | 315 | 440 - 590 | 22 | -20 | |
| | 36 | 355 | 490 - 620 | 21 | | |
| | 40 | 390 | 510 - 650 | 20 | | |
| LT-EH | 32 | 315 | 440 - 590 | 22 | -40 | |
| | 36 | 355 | 490 - 620 | 21 | | |
| | 40 | 390 | 510 - 650 | 20 | | |
| LT-FH | 32 | 315 | 440 - 590 | 22 | -60 | |
| | 36 | 355 | 490 - 620 | 21 | | |
| | 40 | 390 | 510 - 650 | 20 | | |
| 1.5 Ni | | 275 | 490 - 640 | 22 | -80 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3.5 Ni | | 285 | 450 - 610 | 21 | -95 | |
| 5 Ni | | 390 | 540 - 740 | 21 | -110 | |
| 9 Ni | | 490 | 640 - 790 | 18 | -196 | |

Notes:

1 These requirements are applicable to products not exceeding 40 [mm] in thickness. The requirements for thicker products are subject to agreement.

2 The minimum design temperatures at which plates of different thicknesses in the above grades may be used are given in Pt.3, Ch.2, Table 2.4.1 and Pt.5, Ch.4, Table 6.1.2 and Table 6.1.3. Consideration will be given to the use of thicknesses greater than those in the table or to the use of temperatures below - 165°C

## Section 6

## Steels for Boilers and Pressure Vessels

### 6.1 General

6.1.1 The following requirements are for carbon, carbon-manganese and alloy steels intended for use in the construction of boilers and pressure vessels. In addition to specifying mechanical properties at ambient temperature for the purpose of acceptance testing, these requirements also give details of appropriate mechanical properties at elevated temperatures which may be used for design purposes.

6.1.2 Where it is proposed to use a carbon or carbon-manganese steel with a specified minimum tensile strength intermediate to the following specified properties, corresponding minimum values for yield and elongation and mechanical properties at elevated temperatures may be obtained by interpolation.

6.1.3 Carbon and carbon-manganese steels with a specified minimum tensile strength of greater than 490 [N/mm$^2$] but not exceeding 520 [N/mm$^2$] may be accepted provided that details of proposed specifications are submitted for approval.

6.1.4 Where it is proposed to use alloy steels other than those specified herein, details of the specifications are to be submitted for approval. In such cases the specified minimum tensile strength is not to exceed 600 [N/mm$^2$].

6.1.5 Materials intended for use in the construction of the cargo tanks and process pressure vessels, storage tanks for liquefied gases and for other low temperature applications are to comply with the requirements of Sec. 5.

### 6.2 Deoxidation and chemical composition

6.2.1 The method of deoxidation and the chemical analysis of ladle samples is to comply with the requirements of Table 6.2.1.

**Table 6.2.1 : Deoxidation and chemical composition**

| Grade of steel | Deoxidation | Chemical composition per cent | | | | | | |
|---|---|---|---|---|---|---|---|---|
| C and C-Mn steel | | C max. | Si | Mn | P max. | S max. | Al | Residual elements |
| 360 AR | Any method except rimmed steel | 0.18 | 0.50 max. | 0.40-1.30 | 0.040 | 0.04 | - | Cr 0.25 max.<br>Cu 0.30 max.<br>Mo 0.10 max.<br>Ni 0.30 max.<br>Total 0.70 max. |
| 410 AR | | 0.21 | 0.50 max. | 0.40-1.30 | 0.040 | 0.040 | - | |
| 460 AR | | 0.23 | 0.50 max. | 0.80-1.50 | 0.040 | 0.040 | - | |
| 360 | Any method except rimmed steel<br>Killed | 0.17 | 0.35 max. | 0.40-1.20 | 0.035 | 0.035 | -<br>-<br>- | |
| 410 | | 0.20 | 0.35 max. | 0.50-1.30 | 0.035 | 0.035 | | |
| 460 | | 0.20[1] | 0.40 max. | 0.80-1.40 | 0.035 | 0.035 | | |
| 490 | | 0.20[1] | 0.10-0.50 | 0.90-1.60 | 0.035 | 0.035 | | |
| 360 FG | Killed fine grained | 0.17 | 0.35 max. | 0.40-1.20 | 0.035 | 0.035 | See note 2 | |
| 410 FG | | 0.20 | 0.35 max. | 0.50-1.30 | 0.035 | 0.035 | See note 2 | |
| 460 FG | | 0.20[1] | 0.40 max. | 0.80-1.50 | 0.035 | 0.035 | See note 2 | |
| 490 FG | | 0.20[1] | 0.10-0.50 | 0.90-1.60 | 0.035 | 0.035 | See note 2 | |

| Alloy steels | Deoxi-dation | C | Si | Mn | P max. | S max. | Al | Cr | Mo | Residual elements |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 Cr 1/2 Mo 470 | Killed | 0.10-0.18 | 0.15-0.35 | 0.4-0.8 | 0.035 | 0.035 | See note 3 | 0.70-1.30 | 0.40-0.60 | Cu 0.30 max. Ni 0.30 max. |
| 2 1/4 Cr 1 Mo 480 | | 0.08-0.18 | 0.15-0.50 | 0.4-0.8 | 0.035 | 0.035 | See note 3 | 2.00-2.50 | 0.90-1.10 | |

Notes:

1 For thickness greater than 30 [mm], carbon 0.22 percent max.

2 Aluminium (acid soluble) 0.015 per cent min, or Aluminium (total) 0.018 percent min. Niobium, Vanadium or other suitable grain refining elements may be used either in place of or in addition to aluminium.

3 Aluminium (acid soluble or total) 0.020 percent max.

**6.3 Heat treatment, condition of supply**

6.3.1 All materials are to be supplied in a condition complying with the requirements of Table 6.3.1. However, when agreed, material intended for hot forming may be supplied in the as rolled condition.

**Table 6.3.1 : Heat treatment**

| Grade of steel | Condition of supply |
|---|---|
| Carbon and carbon- manganese 360 AR to 460 AR | As rolled, maximum thickness or diameter is 40 [mm] |
| Carbon and carbon- manganese 360 to 490 | Normalized or controlled rolled |
| Carbon and carbon- manganese 360 FG to 490 FG | Normalized or controlled rolled |
| 1Cr 1/2 Mo 470 | Normalized and tempered |
| 2 1/4 Cr 1 Mo 480 | Normalized and tempered |

**6.4 Mechanical tests**

6.4.1 For plates a tensile test specimen is to be taken from one end of each piece when the weight does not exceed 5 tonnes and the length does not exceed 15 [m]. When either of these limits is exceeded, tensile test specimens are to be taken from both ends of each piece. A piece is to be regarded as the rolled product from a single slab or a single ingot, if this is rolled directly into plates.

6.4.2 For strips, tensile test specimens are to be taken from both ends of each coil.

6.4.3 Sections and bars are to be presented for acceptance tests in batches containing not more than 50 lengths, as supplied. The material in each batch is to be of the same section size, from the same cast and in the same condition of supply. One tensile test specimen is to be taken from material representative of each batch, except that additional tests are to be taken when the weight of a batch exceeds 10 tonnes.

6.4.4 Where plates are required for hot forming and it has been agreed that the heat treatment will be carried out by the fabricator, the tests at the steel works are to be made on material which has been cut from the plates and given a normalizing or normalizing and tempering heat treatment in a manner simulating the treatment which will be applied to the plates.

6.4.5 If required by the Surveyors or by the fabricator test material may be given a simulated stress relieving heat treatment prior to the preparation of the test specimens. This has to be stated on the order together with agreed details of the simulated heat treatment and the mechanical properties which can be accepted.

6.4.6 The results of the tensile tests are to comply with the appropriate requirements given in Table 6.4.1, Table 6.4.2 and Table 6.4.3.

| Table 6.4.1 : Mechanical properties for acceptance purposes : carbon and carbon-manganese steels - as rolled | | | | |
|---|---|---|---|---|
| **Grade of steel** | **Thick-ness [mm]** | **Yield stress [N/mm²] min.** | **Tensile strength [N/mm²]** | **Elonga-tion on 5.65√So % min.** |
| 360 AR | ≤ 40 | 190 | 360-480 | 24 |
| 410 AR | ≤ 40 | 215 | 410-530 | 22 |
| 460 AR | ≤ 40 | 240 | 460-580 | 21 |

| Table 6.4.2 : Mechanical properties for acceptance purposes : carbon and carbon-manganese steels-normalized or controlled rolled | | | | |
|---|---|---|---|---|
| **Grade of steel** | **Thickness [mm] (see Note)** | **Yield stress [N/mm²] min.** | **Tensile strength [N/mm²]** | **Elongation on 5.65√So % min.** |
| 360 | > 3 ≤ 16 | 205 | 360 - 480 | 26 |
| | > 16 ≤ 40 | 195 | | 26 |
| | > 40 ≤ 63 | 185 | | 25 |
| 410 | > 3 ≤ 16 | 235 | 410 - 530 | 24 |
| | > 16 ≤ 40 | 225 | | 24 |
| | > 40 ≤ 63 | 215 | | 23 |
| 460 | > 3 ≤ 16 | 285 | 460 - 580 | 22 |
| | > 16 ≤ 40 | 255 | | 22 |
| | > 40 ≤ 63 | 245 | | 21 |
| 490 | > 3 ≤ 16 | 305 | 490 - 610 | 21 |
| | > 16 ≤ 40 | 275 | | 21 |
| | > 40 ≤ 63 | 265 | | 20 |
| 360 FG | > 3 ≤ 16 | 235 | 360 - 480 | 26 |
| | > 16 ≤ 40 | 215 | | 26 |
| | > 40 ≤ 63 | 195 | | 25 |
| 410 FG | > 3 ≤ 16 | 265 | 410 - 530 | 24 |
| | > 16 ≤ 40 | 245 | | 24 |
| | > 40 ≤ 63 | 235 | | 23 |
| 460 FG | > 3 ≤ 16 | 295 | 460 - 580 | 22 |
| | > 16 ≤ 40 | 285 | | 22 |
| | > 40 ≤ 63 | 275 | | 21 |
| 490 FG | > 3 ≤ 16 | 315 | 490 - 610 | 21 |
| | > 16 ≤ 40 | 315 | | 21 |
| | > 40 ≤ 63 | 305 | | 21 |

**Note:**

For thicknesses greater than 63 [mm], the minimum values for yield stress may be reduced by 1 per cent for each 5 [mm] increment in thickness over 63 [mm]. The minimum elongation values may also be reduced one unit, e.g. 20 percent reduced to 19 percent for all thicknesses over 63 [mm]. For thicknesses over 100 [mm], the above values are to be agreed.

**Table 6.4.3 : Mechanical properties for acceptance purposes : alloy steels-normalized and tempered**

| Grade of steel | Thickness [mm] (see Note) | Yield stress [N/mm$^2$] min. | Tensile strength [N/mm$^2$] | Elongation on 5.65√So % min. |
|---|---|---|---|---|
| 1 CR 1/2 Mo 470 | > 3 ≤ 16 | 305 | 470 - 620 | 20 |
| | > 16 ≤ 40 | 305 | | 20 |
| | > 40 ≤ 63 | 305 | | 19 |
| 2 1/4 Cr 1 Mo 480 | > 3 ≤ 16 | 275 | 480 - 630 | 18 |
| | > 16 ≤ 40 | 265 | | 18 |
| | > 40 ≤ 63 | 265 | | 17 |

**Table 6.4.3 (Contd.)**

**Note:**

For thicknesses greater than 63 [mm], the minimum values for yield stress may be reduced by 1 per cent for each 5 [mm] increment in thickness over 63 [mm]. The minimum elongation values may also be reduced one unit, e.g. 20 percent reduced to 19 percent for all thicknesses over 63 [mm]. For thicknesses over 100 [mm], the above values are to be agreed.

**6.5 Mechanical properties for design purposes at elevated temperatures**

6.5.1 Nominal values for the minimum lower yield or 0.2 per cent proof stress at temperatures of 50°C and higher are given in the following tables :

Table 6.5.1 Carbon and carbon manganese steels - As rolled (applicable only when the design temperature does not exceed 350°C).

Table 6.5.2 Carbon and carbon-manganese steels normalized or controlled rolled.

Table 6.5.3 Alloy steels. Normalized and tempered.

6.5.2 These values are intended for design purposes only and verification is not required except for materials complying with National or proprietary specifications where the elevated temperature properties used for design purposes are higher than those given in Table 6.5.1 to Table 6.5.3. The extent of testing in such cases would have to be specially agreed by Designated Authority/Classification Society.

6.5.3 Values for the estimated average stress to rupture in 100,000 hours are given in Table 6.5.4 and may be used for design purposes.

**Table 6.5.1 : Mechanical properties for design purposes - Carbon and carbon - manganese steels - as rolled**

| Grade of steel | Thickness [mm] | Design temperature°C (See Note) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 50 | 10 | 150 | 200 | 250 | 300 | 350 |
| | | Nominal minimum lower yield or 0.2 percent proof stress [N/mm$^2$] | | | | | | |
| 360 AR | ≤ 40 | 154 | 153 | 152 | 145 | 128 | 108 | 102 |
| 410 AR | | 186 | 183 | 181 | 174 | 155 | 134 | 127 |
| 460 AR | | 218 | 213 | 210 | 203 | 182 | 161 | 153 |

Note : Maximum permissible design temperature is 350°C

**Table 6.5.2 : Mechanical properties for design purposes - carbon and carbon - manganese steels - normalized or controlled rolled**

| Grade of steel | Thickness [mm] (see Note) | Design temperature °C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 50 | 100 | 150 | 200 | 250 | 300 | 350 | 400 | 450 |
| | | Nominal minimum lower yield or 0.2 percent proof stress [N/mm$^2$] | | | | | | | | |
| 360 | > 3 ≤ 16 | 183 | 175 | 172 | 168 | 150 | 128 | 117 | 115 | 113 |
| | > 16 ≤ 40 | 173 | 171 | 169 | 162 | 144 | 124 | 117 | 115 | 113 |
| | > 40 ≤ 63 | 166 | 162 | 158 | 152 | 141 | 124 | 117 | 115 | 113 |
| 410 | > 3 ≤ 16 | 220 | 211 | 208 | 201 | 180 | 150 | 142 | 138 | 136 |
| | > 16 ≤ 40 | 204 | 201 | 198 | 191 | 171 | 150 | 142 | 138 | 136 |
| | > 40 ≤ 63 | 196 | 192 | 188 | 181 | 168 | 150 | 142 | 138 | 136 |
| 460 | > 3 ≤ 16 | 260 | 248 | 243 | 235 | 210 | 176 | 168 | 162 | 158 |
| | > 16 ≤ 40 | 235 | 230 | 227 | 220 | 198 | 176 | 168 | 162 | 158 |
| | > 40 ≤ 63 | 227 | 222 | 218 | 210 | 194 | 176 | 168 | 162 | 158 |
| 490 | > 3 ≤ 16 | 280 | 270 | 264 | 255 | 228 | 192 | 183 | 177 | 172 |
| | > 16 ≤ 40 | 255 | 248 | 245 | 237 | 214 | 192 | 183 | 177 | 172 |
| | > 40 ≤ 63 | 245 | 240 | 236 | 227 | 210 | 192 | 183 | 177 | 172 |
| 360 FG | > 3 ≤ 16 | 214 | 204 | 185 | 165 | 145 | 127 | 116 | 110 | 106 |
| | > 16 ≤ 40 | 200 | 196 | 183 | 164 | 145 | 127 | 116 | 110 | 106 |
| | > 40 ≤ 63 | 183 | 179 | 172 | 159 | 145 | 127 | 116 | 110 | 106 |
| 410 FG | > 3 ≤ 16 | 248 | 235 | 216 | 194 | 171 | 152 | 141 | 134 | 130 |
| | > 16 ≤ 40 | 235 | 228 | 213 | 192 | 171 | 152 | 141 | 134 | 130 |
| | > 40 ≤ 63 | 222 | 215 | 204 | 188 | 171 | 152 | 141 | 134 | 130 |
| 460 FG | > 3 ≤ 16 | 276 | 262 | 247 | 223 | 198 | 177 | 167 | 158 | 153 |
| | > 16 ≤ 40 | 217 | 260 | 242 | 220 | 198 | 177 | 167 | 158 | 153 |
| | > 40 ≤ 63 | 262 | 251 | 236 | 217 | 198 | 177 | 167 | 158 | 153 |
| 490 FG | > 3 ≤ 16 | 297 | 284 | 265 | 240 | 213 | 192 | 182 | 173 | 168 |
| | > 16 ≤ 40 | 293 | 279 | 260 | 237 | 213 | 192 | 182 | 173 | 168 |
| | > 40 ≤ 63 | 286 | 272 | 256 | 234 | 213 | 192 | 182 | 173 | 168 |

Note : For thicknesses greater than 63 [mm], the values for lower yield or 0.2 percent stress are to be reduced by 1 percent for each 5 [mm] increment in thickness upto 100 [mm]. For thicknesses over 100 [mm], the values are to be agreed and verified by test.

**Table 6.5.3 : Mechanical properties for design purposes : alloy steels-normalized tempered**

| Grade of steel | Thickness [mm] (see Note) | Design temperature °C | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 50 | 100 | 200 | 300 | 350 | 400 | 450 | 500 | 550 | 600 |
| | | Nominal minimum lower yield or 0.2 percent proof stress [N/mm$^2$] | | | | | | | | | |
| 1 Cr 1/2 Mo 470 | 3 ≤ 63 | 284 | 270 | 248 | 216 | 203 | 199 | 194 | 188 | 181 | 174 |
| 2 1/4 Cr 1 Mo 480 | 3 ≤ 63 | 255 | 249 | 233 | 219 | 212 | 207 | 194 | 180 | 160 | 137 |

Note : For thicknesses greater than 63 [mm], the values for lower yield or 0.2 percent stress are to be reduced by 1 percent for each 5 [mm] increment in thickness upto 100 [mm]. For thicknesses over 100 [mm], the values are to be agreed and verified by test.

**Table 6.5.4 : Mechanical properties for design purposes : estimated average values for stress to rupture in 100,000 hours [N/mm$^2$]**

| Temp. °C | Grades of steel | |
|---|---|---|
| | Carbon and carbon-manganese | Alloy Steels |

| | 360 FG<br>410 FG<br>460 FG | 360<br>410<br>460 | 490<br>490 FG<br>510 FG | 1 Cr 1/2 Mo 470 | 2 1/4 Cr 1 Mo 480 |
|---|---|---|---|---|---|
| 380 | 171 | 219 | 227 | - | - |
| 390 | 155 | 196 | 203 | - | - |
| 400 | 141 | 173 | 179 | - | - |
| 410 | 127 | 151 | 157 | - | - |
| 420 | 114 | 129 | 136 | - | - |
| 430 | 102 | 109 | 117 | - | - |
| 440 | 90 | 92 | 100 | - | - |
| 450 | 78 | 78 | 85 | - | 221 |
| 460 | 67 | 67 | 73 | - | 204 |
| 470 | 57 | 57 | 63 | - | 186 |
| 480 | 47 | 48 | 55 | 210 | 170 |
| 490 | 36 | - | 47 | 177 | 153 |
| 500 | - | - | - | 146 | 137 |
| 510 | - | - | - | 121 | 122 |
| 520 | - | - | - | 99 | 107 |
| 530 | - | - | - | 81 | 93 |
| 540 | - | - | - | 67 | 79 |
| 550 | - | - | - | 54 | 69 |
| 560 | - | - | - | 43 | 59 |
| 570 | - | - | - | 35 | 51 |
| 580 | - | - | - | - | 44 |

## Section 7

## Steels for Machinery Structures

### 7.1 General

7.1.1 Steel plates, strips, sections or bars intended for use in the construction of welded machinery structures are to comply with one of the following alternatives:

a) Any grade of normal strength structural steel or high strength structural steel as detailed in Sec. 2 and 3.

b) Any grade of carbon or carbon-manganese steel as detailed in Sec. 6 except that for this application batch testing is acceptable and the same is to be carried out in accordance with the requirements of Sec. 2.

## Section 8

## Plates with Specified minimum through Thickness Properties

## (‘Z’ quality)

### 8.1 General

8.1.1 Following requirements are for special quality plate material with improved ductility in the through thickness or "Z direction.

8.1.2 The use of this material known as ‘Z’ quality steel, is recommended when plate material, intended for welded construction, will be subject to significant strain in a direction perpendicular to the rolled surfaces. These strains are usually associated with

thermal contraction and restraint during welding, particularly for full penetration "T"- butt welds but may also be associated with loads applied in service or during construction. Where these strains are of sufficient magnitude, lamellar tearing may occur. Two 'Z' quality steels are specified; Z25 for normal ship applications and 'Z35' for more severe applications.

Through thickness properties are characterized by specified values for reduction of area in a through thickness tensile test.

8.1.3 This special quality material is to comply with the requirements of Sec. 2, 3, 4, 5, 6 and 7 as appropriate and the following additional requirements.

**8.2 Manufacture**

8.2.1 All plates are to be manufactured at works which have been approved by Designated Authority/Classification Society for this quality of material. Also refer Chapter 1, Section 1, Cl. 1.3.2.

8.2.2 The sulphur content is not to exceed 0.008 per cent, as determined by ladle analysis. It is recommended that the steel should be efficiently vacuum de-gassed.

**8.3 Test material**

8.3.1 Unless otherwise agreed, through thickness tensile tests are only required for plate materials where the thickness exceeds 15 [mm]. A test sample large enough to provide six test specimens are to be cut from the centre of one end of each rolled piece representing the batch. (See Fig.8.3.1). Where appropriate the end selected should be representative of the top end of an ingot or the start of a concast strand. Generally three through thickness tensile test specimens are to be prepared while the rest of the sample remains for possible retests.

8.3.2 The batch size is to be determined depending on the product and sulphur content as given in Table 8.3.2.

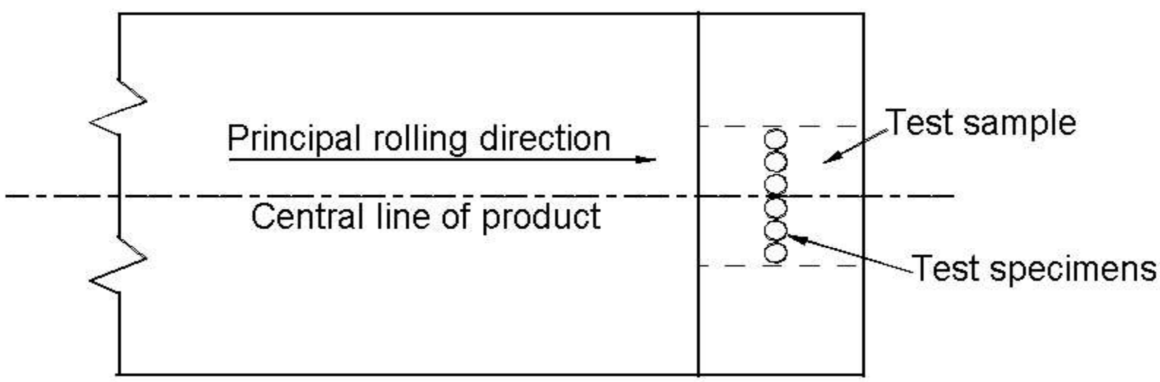



**Fig.8.3.1 : Plate and wide flat sampling position**

**Table 8.3.2 : Batch size dependent on product and sulphur content**

| Product | S > 0.005% | S ≤ 0.005% |
|---|---|---|
| Plates | Each piece (parent plate) | Maximum 50t of products of the same cast, thickness and heat treatment |
| Wide flats of nominal thickness ≤ 25 mm | Maximum 10t of products of the same cast, thickness and heat treatment | Maximum 50t of products of the same cast, thickness and heat treatment |
| Wide flats of nominal thickness > 25 mm | Maximum 20t of products of the same cast, thickness and heat treatment | Maximum 50t of products of the same cast, thickness and heat treatment |

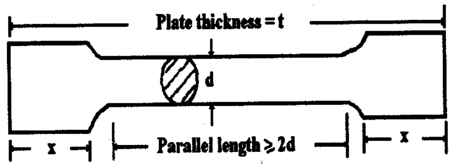
**8.4 Dimensions of through thickness tensile test specimens**

8.4.1 At the option of the steel maker test specimens (Fig.8.4.1a) or test specimens with welded extensions (Fig.8.4.1b) may be used. For both types of test specimens, the diameter of the parallel portion is not

to be less than 6 [mm] when plate thickness is less than or equal to 25 [mm] and 10 [mm] when the plate thickness is greater than 25 [mm].

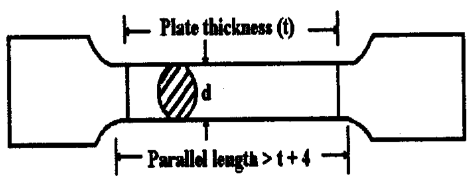
Alternatively, round test specimens, including those with welded extensions, may be prepared in accordance with a recognized standard.

8.4.2 The tolerances on specimen dimensions are to be in accordance with ISO 6892-98 or other recognised standards as appropriate.




t = thickness of plate [mm]
d = 6 mm; when 15 mm ≤ t ≤ 25 [mm]
d = 10 mm min. when t > 25 [mm]
x = 5 mm max. when d = 6 [mm]
x = 8 mm max. when d = 10 [mm]

**Fig 8.4.1 (a) : Plain test specimen**




t = Thickness of plate [mm]
d = 6 mm; when 15 mm ≤ t ≤ 25 [mm]
d = 10 mm when t 25 [mm]

**Fig 8.4.1 (b) : Test specimen with welded extension**

**8.5 Mechanical tests**

8.5.1 The acceptable minimum average value for the reduction of area of the three tensile test specimens taken in the through thickness direction are given in Table 8.5.1. Only one individual value may be below the minimum average, but not less than the minimum individual value for the appropriate grade.

**Table 8.5.1 : Reduction of area acceptance values**

| Grade | Z25 | Z35 |
|---|---|---|
| Minimum average | 25% | 35% |
| Minimum individual | 15% | 25% |

8.5.2 A value less than minimum individual value will require rejection of the piece. However, in case of batch testing each remaining piece in the batch may be individually tested.

8.5.3 Depending on the test results, retest may be permitted in the cases shown in Fig.8.5.3. In these instances, three more tensile tests are to be taken from the remaining test sample. The average of all 6 tensile tests is to be greater than the required minimum average with not more than two results below the minimum average.

In case of failure after retest, either the batch represented by the piece is rejected or each piece within batch may be retested.

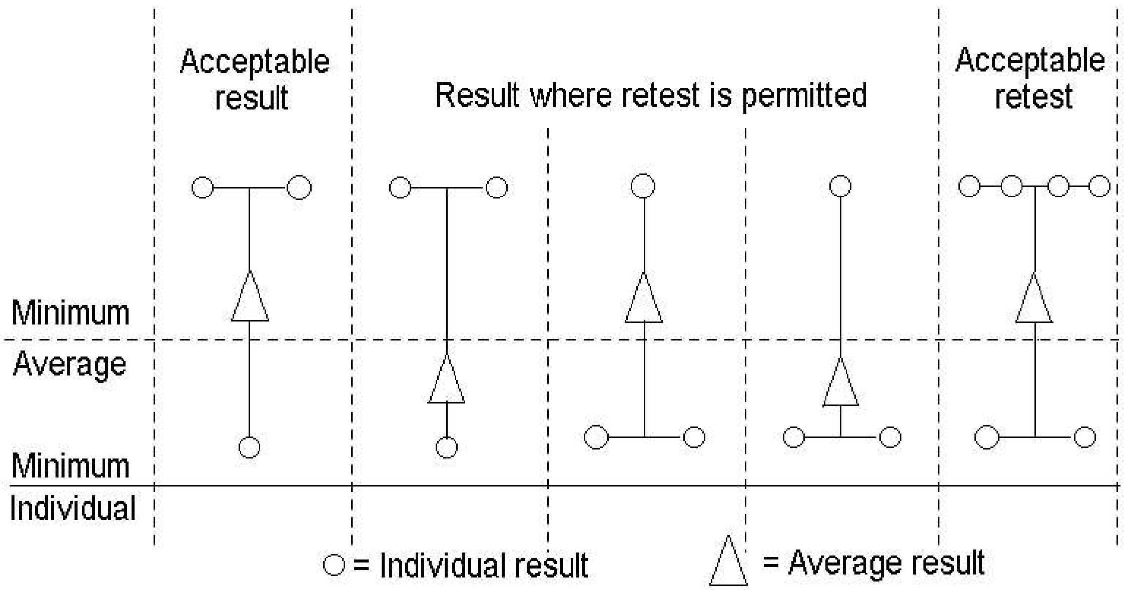



**Fig.8.5.3 : Diagram showing acceptance / rejection and retest criteria**

**8.6 Non-destructive examination**

8.6.1 All special 'Z' quality plates are to be ultrasonically tested in the final supply condition, with a probe of frequency 4 MHz. The ultrasonic testing is to be carried out in accordance with either EN 10160:1999 Level S1/E1 or ASTM A578:2017 Level C.

## Section 9

## Austenitic and Duplex Stainless Steels

**9.1 Scope**

9.1.1 This section gives the requirements for rolled products in austenitic and duplex (austenite plus ferrite) stainless steels intended for use in the construction of cargo tanks, storage tanks and process pressure vessels for chemicals and liquefied gases.

9.1.2 Austenitic stainless steels are suitable for applications where the lowest design temperature is not lower than –165°C.

9.1.3 Austenitic stainless steels are also suitable for service at elevated temperatures and for such applications the proposed specification should contain, in addition to the requirements of 9.1.6, minimum values for 0.2 and 1.0 per cent proof stresses at the design temperature.

9.1.4 Duplex stainless steels are suitable for applications where the lowest design temperature is above 0°C. Any requirement to use duplex stainless steels below 0°C will be subject to special consideration.

9.1.5 Duplex stainless steels are also suitable for service at temperatures upto 300°C and for such applications the proposed specification should include, in addition to the requirements of 9.1.6, a minimum value for 0.2 per cent proof stress at the design temperature.

9.1.6 A specification giving details of the chemical composition, heat treatment and mechanical properties, including for the austenitic grades, both the 0.2 and 1.0 percent proof stresses, is to be submitted for consideration and approval.

### 9.2 Chemical composition

9.2.1 The chemical composition of ladle samples is to comply with the requirements given in Table 9.2.1.

### 9.3 Heat treatment

9.3.1 All materials are to be supplied in the solution treated condition.

**Table 9.2.1 : Chemical composition**

| Type and grade of steel | Chemical composition % (see Note) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | C max | Si max | Mn max | P max | S max | Cr | Ni | Mo | N | Other |
| Austenitic | 0.03 | } | } | } | } | 17.0-20.0 | 8.0-13.0 | - | 0.10 | - |
| 304L | “ | } | } | } | } | 17.0-20.0 | 3.0-12.0 | - | 0.10-0.22 | - |
| 304LN | “ | } | } | } | } | 16.0-18.5 | 10.0-15.0 | 2.0-3.0 | 0.10 | - |
| 316L | “ | 1.0 | 2.0 | 0.045 | 0.03 | 16.0-18.5 | 10.0-14.5 | 2.0-3.0 | 0.10-0.22 | - |
| 316LN | “ | } | } | } | } | 18.0-20.0 | 11.0-15.0 | 3.0-4.0 | 0.10 | - |
| 317L | “ | } | } | } | } | 18.0-20.0 | 12.5-15.0 | 3.0-4.0 | 0.10-0.22 | - |
| 317LN | 0.06 | } | } | } | } | 17.0-19.0 | 9.0-12.0 | - | 0.10 | 5xC≤Ti≤0.7 |
| 321 | 0.06 | } | } | } | } | 17.0-19.0 | 9.0-13.0 | - | 0.10 | 10xC≤Nb≤1.0 |
| 347 | | | | | | | | | | |
| Duplex | 0.03 | 1.0 | 2.0 | 0.03 | 0.02 | 21.0-23.0 | 4.5-6.5 | 2.5-3.5 | 0.08-0.20 | - |
| UNS S31803 | 0.03 | 0.80 | 1.2 | 0.035 | 0.02 | 24.0-26.0 | 6.0-8.0 | 3.0-5.0 | 0.24-0.32 | Cu 0.50 max. |
| UNS S32750 | | | | | | | | | | |

### 9.4 Mechanical tests

9.4.1 Tensile test specimens are to be taken in accordance with the appropriate requirements of 5.4 and 6.4.1.

9.4.2 For the duplex grades, one set of three Charpy V-notch impact test specimens machined in the longitudinal direction from each tensile test piece is to be tested at –20°C. The average energy value of the three specimens is to be not less than 41 Joules.

For austenitic grades of steel, impact tests are only required for design temp. below –105°C. In such cases, impact tests carried out at a temperature of –196°C on a set of three charpy V-notch specimens are to comply with the following:

a) Plates : Transverse test pieces; minimum average energy value 27 Joules.

b) Strips, sections and bars : Longitudinal test pieces, minimum average energy value 41 Joules.

9.4.3 Where standard subsidiary Charpy V-notch test specimens are necessary, see Chapter 2, Sec.3.1.2.

9.4.4 The results of all tensile tests are to comply with the requirements of Table 9.4.1 or the approved specification.

### 9.5 Through thickness tests

9.5.1 Where material will be strained in a through thickness direction during welding or in service, through thickness tests are required on plates over 10 [mm] thick in all the grades of steels listed in Table 9.2.1, apart from Grades 304L, 304LN, 321 and 347.

9.5.2 Testing is to conform with the requirements of Section 8, with the exception given in 9.5.3.

9.5.3 When the reduction in area is less than 35 per cent, metallographic or other evidence is required to show that no significant amount of any detrimental phase, such as sigma, is present.

**Table 9.4.1 : Mechanical properties for acceptance purposes**

| Type and grade of steel | 0.2% proof stress [N/mm$^2$] minimum | 1% proof stress [N/mm$^2$] minimum | Tensile strength [N.mm$^2$] minimum | Elongation on 5.65 $\sqrt{S_o}$ % minimum |
|---|---|---|---|---|
| Austenitic | | | | |
| 304L | 170 | 210 | 485 | 40 |

| | | | | |
|---|---|---|---|---|
| 304LN | 205 | 245 | 515 | 40 |
| 316L | 170 | 210 | 485 | 40 |
| 316LN | 205 | 245 | 515 | 40 |
| 317L | 205 | 245 | 515 | 40 |
| 317LN | 240 | 280 | 550 | 40 |
| 321 | 205 | 245 | 515 | 40 |
| 347 | 205 | 245 | 515 | 40 |
| Duplex | | | | |
| UNS S 31803 | 450 | - | 620 | 25 |
| UNS S 32750 | 550 | - | 795 | 15 |

**9.6 Intergranular corrosion tests**

9.6.1 For certain specific applications such as storage tanks for chemicals, it may be necessary to demonstrate that the material used is not susceptible to intergranular corrosion resulting from grain boundary precipitation of chromium-rich carbides.

9.6.2 When required, one test of this type is to be carried out for each tensile test. The testing is to be carried out in accordance with ASTM A262, practice E, copper-copper sulphate-sulphuric acid or another recognized standard. The bent specimen is to be free from cracks indicating the presence of intergranular attack. The material for the test is to be taken adjacent to that for the tensile test.

**9.7 Dimensional tolerances**

9.7.1 The minimum tolerance on thickness is to be as given in Table 1.4.1.

**9.8 Clad plates**

9.8.1 Carbon or carbon-manganese steel plates, clad on one or both surfaces with a suitable grade of austenitic or duplex stainless steel, may be used for the construction of cargo or storage tanks for chemicals.

9.8.2 The carbon or carbon-manganese steel base plates are to comply with the requirements of Section 6 and the austenitic or duplex cladding material generally with the requirements of this section.

9.8.3 The process of manufacture is to be specially approved and may be either by roll cladding or by explosive bonding.

9.8.4 Where the use of clad materials is proposed, the material specification is to be submitted for consideration, together with details of the extent and the acceptance standards for non-destructive examination.

**9.9 Identification of materials**

9.9.1 The particulars detailed in 1.12 are to be marked on all materials which have been accepted.

**9.10 Certification of materials**

9.10.1 Each test certified or shipping statement is to give the information detailed in 1.13, together with general details of heat treatment and where applicable, the results obtained from intercrystalline corrosion tests. The chemical composition is to include the content of all the elements detailed in Table 9.2.1.

## Chapter 4

## Steel Castings

***Contents***

***Section***

## Section 1

## General Requirements

### 1.1 Scope

1.1.1 All important steel castings, as defined in the relevant construction rules are to be manufactured and tested in accordance with the requirements of this Chapter.

1.1.2 Where required by the relevant requirements dealing with design and construction, castings are to be manufactured and tested in accordance with Ch.1 and Ch.2, together with the general requirements given in this Section and the appropriate specific requirements given in Sec.2 to 5.

1.1.3 As an alternative to 1.1.3, castings which comply with national or proprietary specifications may be accepted provided that these specifications give reasonable equivalence to the requirements of this chapter or alternatively are approved for a specific application. Generally, survey and certification are to be carried out in accordance with the requirements of Ch.1.

### 1.2 Manufacture

1.2.1 Castings are to be made by manufacturer approved by Designated Authority/Classification Society. Also refer Chapter 1, Section 1, Cl. 1.3.2.

1.2.2 The steel is to be manufactured by a process approved by Designated Authority/Classification Society.

1.2.3 All flame cutting, scarfing or arc-air gouging to remove surplus metal is to be undertaken in accordance with recognized good practice and is to be carried out before the final heat-treatment. Preheating is to be employed when necessitated by the chemical composition and/or thickness of the castings. If necessary, the affected areas are to be either machined or ground smooth.

1.2.4 For certain components including steel castings subjected to surface hardening process, the proposed method of manufacture may require special approval by Designated Authority/Classification Society.

1.2.5 When two or more castings are joined by welding to form a composite the proposed welding procedure is to be submitted for approval. Welding procedure qualification tests may be required.

### 1.3 Quality of castings

1.3.1 All castings are to be free from surface or internal defects which would be prejudicial to their proper application in service. The surface finish is to be in accordance with good practice and any specific requirements of the approved plan.

1.3.2 The surfaces are not to be treated in any way which may obscure defects.

### 1.4 Chemical composition

1.4.1 All castings are to be made from killed steel and the chemical composition is to be appropriate for the type of steel and the mechanical properties specified for the castings. The chemical composition of each heat is to be determined by the manufacturer on a sample taken preferably during the pouring to the heat. When multiple heats are tapped into a common ladle, the ladle analysis shall apply.

### 1.5 Inspection

1.5.1 All castings are to be cleaned and adequately prepared for examination; suitable methods include pickling, caustic cleaning, wire brushing, local grinding, shot or sand blasting. The surfaces are not to be hammered, peened or treated in any way which may obscure defects.

1.5.2 Before acceptance all castings are to be presented to the Surveyors for visual examination. Where applicable, this is to include the examination of internal surfaces. Unless otherwise agreed, the verification of dimensions is the responsibility of the manufacturer.

1.5.3 When required by the relevant construction Rules, or by the approved procedure for welded composite components appropriate non-destructive testing is also to be carried out before acceptance and the results are to be reported by the manufacturer.

1.5.4 When required by the relevant construction Rules castings are to be pressure tested before final acceptance. These tests are to be carried out in the presence of the Surveyors and are to be to their satisfaction.

1.5.5 In the event of any casting proving defective during subsequent machining or testing, it is to be rejected notwithstanding any previous certification.

### 1.6 Hydraulic pressure testing

1.6.1 When required by the relevant construction Rules, castings are to be pressure tested before final acceptance. These tests are to be carried out in the presence of the Surveyors and are to be to their satisfaction.

### 1.7 Rectification of defective castings

*1.7.1 General*

i) Steel casting defects are to be removed with or without weld repair before considering suitable for use subject to approval of Designated Authority/Classification Society.

ii) Where the defective area is to be repaired by welding, the excavations are to be suitably shaped to allow good access for welding. The resulting grooves are to be subsequently ground smooth and complete elimination of the defective material is to be verified by MT or PT.

iii) Shallow grooves or depressions resulting from the removal of defects may be accepted provided that they will cause no appreciable reduction in the strength of the casting. The resulting groves or depressions are to be subsequently ground smooth and complete elimination of the defective material is to be verified by MT or PT. Small surface irregularities sealed by welding are to be treated as weld repairs.

iv) The manufacturer is to maintain full records detailing the extent and location of repairs made to each casting and details of weld procedures and heat treatments applied for repairs. These records are to be available to the Surveyor and copies provided on request.

*1.7.2 Weld repairs*

When it has been agreed that a casting can be repaired by welding the following requirements apply:

i) Before welding is started, full details of the extent and location of the repair, the proposed welding procedure, heat treatment and subsequent inspection procedures are to be submitted for approval:

ii) All castings in alloy steels and all castings for crankshafts are to be suitably pre-heated prior to welding. Castings in carbon or carbon-manganese steel may also require to be pre-heated depending on their chemical composition and the dimensions and position of the weld repairs.

iii) Welding s to be done under cover in positions free from draughts and adverse weather conditions by qualified welders with adequate supervision. As far as possible, all welding is to be carried out in the downhand (flat) position.

iv) The welding consumables used are to be of an appropriate composition, giving a weld deposit with mechanical properties similar and in no way inferior to those of the parent castings. Welding procedure tests are to be carried out by the manufacturer to demonstrate that satisfactory mechanical properties can be obtained after heat treatment as detailed in Sec.2.

v) After welding has been completed the castings are to be given either a suitable heat treatment in accordance with the requirements of Sec.2 or a stress relieving heat treatment at a temperature of not less than 550°C. The type of heat treatment employed will be dependent on the chemical composition of the casting and he dimensions, positions and nature of the repairs.

vi) Subject to the prior agreement of Designated Authority/Classification Society special consideration may be given to the omission of postweld heat treatment or to the acceptance of local stress relieving heat treatment where the repaired area is small and machining of the casting has reached an advanced stage.

vii) On completion of heat treatment the weld repairs and adjacent material are to be ground smooth and examined by magnetic particle or liquid penetrant testing. Supplementary examination by ultrasonics or radiography may also be repaired depending on the dimensions and nature of the original defect. Satisfactory results are to be obtained from all forms of non-destructive testing used.

**1.8 Identification of castings**

1.8.1 The manufacturer is to adopt a system of identification which will enable all finished castings to be traced to the original cast and Surveyors are to be given full facilities for so tracing the castings when required.

1.8.2 Before acceptance, all castings which have been tested and inspected with satisfactory results are to be clearly marked by the manufacturer with the following particulars:

i) Steel quality.

ii) Identification number, cast number or other marking which will enable the full history of the casting to be traced.

iii) Manufacturer's name or trade mark.

iv) The Designated Authority/Classification Society brand name.

v) Abbreviated name of the Designated Authority/Classification Society local office.

vi) Personal stamp of Surveyors responsible for inspection.

vii) Where applicable, test pressure.

1.8.3 When small castings are manufactured in large numbers, modified arrangements for identification may be specially agreed with Designated Authority/Classification Society.

**1.9 Certification**

1.9.1 The manufacturer is to provide the Surveyor with a test certificate or shipping statement giving the following particulars for each casting or batch of castings which has been accepted:-

a) Purchaser's name and order number;

b) Description of castings and steel quality;

c) Identification number;

d) Steel making process, cast number and chemical analysis of ladle samples;

e) Results of mechanical testing;

f) General details of heat treatment;

g) Where applicable, test pressure.

## Section 2

## Hull and Machinery Steel Castings for General Applications

### 2.1 Scope

2.1.1 The requirements given in this section are applicable to steel castings intended for hull and machinery applications such as stern frames, rudder frames, crankshafts, turbine casings, bedplates, etc.

2.1.2 These requirements are applicable only to steel castings where the design and acceptance tests are related to mechanical properties at ambient temperature. For other applications, additional requirements may be necessary, especially when the castings are intended for service at low or elevated temperatures.

2.1.3 Where the use of alloy steel castings is proposed full details of the chemical composition, heat treatment, mechanical properties, testing inspection and rectification are to be submitted for approval of Designated Authority/Classification Society.

### 2.2 Chemical composition

2.2.1 For carbon and carbon-manganese steel castings the chemical composition is to comply with the overall limits given in Table 2.2.1 or where applicable, the requirements of the approved specification.

2.2.2 Unless otherwise required, suitable grain refining elements such as aluminium may be used at the discretion of the manufacturer. The content of such elements is to be reported.

**Table 2.2.1 : Chemical composition limits for hull and machinery steel castings (%)**

| Steel type | Applications | C (max.) | Si (max.) | Mn | S (max.) | P (max.) | Residual elements (max.) | | | | Total residuals (max.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cu | Cr | Ni | Mo | |
| C, C-Mn | Castings for non-welded construction | 0.40 | 0.60 | 0.50 – 1.60 | 0.040 | 0.040 | 0.30 | 0.30 | 0.40 | 0,15 | 0.80 |
| | Castings for welded construction | 0.23 | 0.60 | 1.60 max. | 0.040 | 0.040 | 0.30 | 0.30 | 0.40 | 0.15 | 0.80 |

### 2.3 Heat treatment

2.3.1 Castings are to be supplied in one of the following conditions:

Fully annealed

Normalised

Normalised and tempered

Quenched and tempered

The tempering temperature is not less than 550°C.

2.3.2 Castings or component such as crankshafts and engine bedplates, where dimensional stability and freedom from internal stresses are important are to be given a stress relief heat treatment. This is to be carried out at a temperature of not less than 550°C followed by furnace cooling to 300°C or lower.

2.3.3 Heat treatment is to be carried out in properly constructed furnaces which are efficiently maintained and have adequate means for control and recording of temperature. The furnace dimensions are to be such as to allow the whole casting to be uniformly heated to the necessary temperature. In the case of very large castings alternative methods for heat treatment will be specially considered by Designated Authority/Classification Society. Sufficient thermocouples are to be connected to the furnace charge to measure and record that its temperature is adequately uniform unless the temperature uniformity of the furnace is verified at regular intervals.

2.3.4 If a casting is locally reheated or any straightening operation is performed after the final heat treatment, a subsequent stress relieving heat treatment may be required in order to avoid the possibility of harmful residual stresses.

2.3.5 The manufacturer's works is to maintain records of heat treatment identifying the furnace used, furnace charge, date, temperature and time at temperature. The records are to be presented to the Surveyor on request.

### 2.4 Mechanical tests

2.4.1 Test material, sufficient for the required tests and for possible retest purposes is to be provided for each casting or batch of castings.

2.4.2 At least one test sample is to be provided for each casting. Unless otherwise agreed these test samples are to be either integrally cast or gated to the castings and are to have a thickness of not less than 30 [mm].

2.4.3 Where the casting is of complex design or where the finished mass exceeds 10 tonnes, two test samples are to be provided. Where large castings are made from two or more casts, which are not mixed in a ladle prior to pouring, two or more test samples are to be provided corresponding, the number of the casts involved. These are to be integrally cast at locations as widely separated as possible.

2.4.4 For castings where the method of manufacture has been specially approved by Designated Authority/Classification Society in accordance with 1.2.4, the number and position of test samples is to be agreed with Designated Authority/Classification Society having regard to the method of manufacture employed.

2.4.5 As an alternative to 2.4.2, where a number of small castings of about the same size, each of which is under 1000 [kg] in mass are made from one cast and heat treated in the same furnace charge, a batch testing procedure may be adopted using separately cast test samples of suitable dimensions. At least one test sample is to be provided for each batch of castings.

2.4.6 The test samples are not to be detached from the casting until the specified heat treatment has been completed and they have been properly identified.

2.4.7 One tensile test specimen is to be taken from each test sample.

2.4.8 The preparation of test specimens and the procedures used for mechanical testing are to comply with the relevant requirements of Ch.2. Unless otherwise agreed all tests are to be carried out in the presence of the Surveyors.

**2.5 Mechanical properties**

2.5.1 Table 2.5.1 gives the minimum requirements for yield stress, elongation and reduction of area corresponding to different strength levels. Where it is proposed to use a steel with a specified minimum tensile strength intermediate to those given, corresponding minimum values for the other properties may be obtained by interpolation.

2.5.2 Castings may be supplied to any specified minimum tensile strength selected within the general limits detailed in Table 2.5.1 but subject to any additional requirements of the relevant construction rules.

2.5.3 The mechanical properties are to comply with the requirements of Table 2.5.1, appropriate to the specified minimum tensile strength or, where applicable, the requirements of the approved specification.

2.5.4 Where the result of a tensile test does not comply with the requirements, two additional tests may be taken. If satisfactory results are obtained from both of these additional tests the casting or batch of castings is acceptable. If one or both retests fail the castings or batch of castings is to be rejected.

2.5.5 The additional tests detailed in 2.5.4 are to be taken, preferably from the same, but alternatively from another, test sample representative of the casting or batch of castings.

2.5.6 At the option of the manufacturer, when a casting or batch of castings has failed to meet the test requirements, it may be reheat treated and re-submitted for acceptance tests.

**Table 2.5.1 : Mechanical properties for hull and machinery steel castings**

| Specified minimum tensile strength (1) [N/mm$^2$] | Yield stress [N/mm$^2$] min. | Elongation on 5.65 √So (%) min. | Reduction of area (%) min. |
|---|---|---|---|
| 400 | 200 | 25 | 40 |
| 440 | 220 | 22 | 30 |
| 480 | 240 | 20 | 27 |
| 520 | 260 | 18 | 25 |
| 560 | 300 | 15 | 20 |
| 600 | 320 | 13 | 20 |

Note:

(1) A tensile strength range of 150 [N/mm$^2$] may additionally be specified.

## Section 3

## Ferritic Steel Castings for Low Temperature Services

**3.1 General**

3.1.1 This Section gives the requirements for castings in carbon-manganese and nickel alloy steels intended for use in liquefied gas piping systems where the design temperature is lower than 0°C and for other applications where guaranteed impact properties at low temperatures is required.

3.1.2 Other steel types may also be accepted upon consideration in each case.

**3.2 Chemical composition**

3.2.1 The chemical composition of ladle samples is to comply with the overall limits given in Table 3.2.1. The carbon-manganese steel is to be fine grain treated.

**Table 3.2.1 : Chemical composition of ferritic steel castings for low temperature service**

| Type of steel | Chemical composition % | | | | | | |
|---|---|---|---|---|---|---|---|
| | C max. | Si max. | Mn | S max. | P max. | Ni | Residual elements max. |
| Carbon-manganese | 0.25 | 0.60 | 0.70-1.60 | 0.030 | 0.030 | 0.80 max. | |
| $2\frac{1}{4}$ Ni | 0.25 | 0.60 | 0.50-0.80 | 0.025 | 0.030 | 2.00-3.00 | Cr 0.25<br>Cu 0.30<br>Mo 0.15<br>V 0.03<br>Total 0.60 |
| $3\frac{1}{2}$ Ni | 0.15 | 0.60 | 0.50-0.80 | 0.020 | 0.025 | 3.00-4.00 | |

### 3.3 Heat treatment

3.3.1 Castings are to be supplied in one of the following conditions :

a) normalized.

b) normalized and tempered.

c) quenched and tempered.

### 3.4 Mechanical tests

3.4.1 The mechanical properties of steel castings are to comply with requirements given in Table 3.4.1.

3.4.2 The tensile test is to be carried out at ambient temperature and the impact tests are to be carried out at the temperature specified in the table.

3.4.3 The average energy value from a set of three charpy V-notch impact test specimens is not to be lower than the required average value given in Table 3.4.1. One individual value may be less than the required average value provided that it is not less than 70 per cent of this average value.

### 3.5 Non-destructive testing

3.5.1 The non-destructive testing of castings is to be carried out in accordance with the appropriate requirements of 1.7 and additionally agreed between the manufacturer, purchaser and Surveyor.

**Table 3.4.1 : Mechanical properties for acceptance purposes : ferritic steel castings for low temperature service**

| Type of steel | Grade | Yield stress [N/mm$^2$] min. | Tensile strength [N/mm$^2$] | Elongation on 5.65√So% min. | Reduction of area % min. | Charpy V-notch impact test | |
|---|---|---|---|---|---|---|---|
| | | | | | | Test temp.°C | Average energy J min. |
| Carbon-manganese | 400 | 200 | 400 - 550 | 25 | 40 | -60 | |
| | 430 | 215 | 430 - 580 | 23 | 35 | (see Note) | 27 |
| | 450 | 230 | 460 - 610 | 22 | 30 | | |
| $2\frac{1}{4}$ Ni | 490 | 275 | 490 - 640 | 20 | 35 | -70 | 34 |
| $3\frac{1}{2}$ Ni | 490 | 275 | 490 - 640 | 20 | 35 | -95 | 34 |

Note : The temperature for carbon-maganese steels may be 5°C below the design temperature if the latter is above -55°C, with a maximum test temperature of -20°C.

## Section 4

## Steel Castings for Propellers

### 4.1 Scope

4.1.1 These requirements are applicable to the manufacture, inspection and repair procedures of cast steel propellers, blades and bosses.

4.1.2 Where the use of alternative alloys is proposed, particulars of chemical composition, mechanical properties and heat treatment are to be submitted for approval.

4.1.3 These requirements may also be used for the repair of propellers damaged in service, subject to prior approval of Designated Authority/Classification Society.

**4.2 Foundry Approval**

4.2.1 All propellers, blades and bosses are to be manufactured by foundries approved in accordance with Ch.1. Also refer Chapter 1, Section 1, Cl. 1.3.2. The castings are to be manufactured and tested in accordance with the requirements of this Section.

4.2.2 It is the manufacturer's responsibility to assure that effective quality, process and production controls during manufacturing are adhered to within the manufacturing specification. The manufacturing specification is to be submitted to Designated Authority/Classification Society at the time of initial approval, and is to at least include the following particulars:

a) description of the foundry facilities,

b) steel material specification,

c) runner and feeder arrangements,

d) manufacturing procedures,

e)non-destructive testing and repair procedures.

4.2.3 The scope of the approval test is to be agreed with Designated Authority/Classification Society. This is to include the presentation of cast test coupons of the propeller materials in question for approval testing in order to verify that the chemical composition and the mechanical properties of these materials comply with this section.

4.2.4 The foundry is to have an adequately equipped laboratory, manned by experienced personnel, for the testing of moulding materials chemical analyses, mechanical testing, microstructural testing of metallic materials and non-destructive testing. Where testing activities are assigned to other companies or other laboratory, additional information required by Designated Authority/Classification Society is to be included.

**4.3 Quality of castings**

4.3.1 Freedom from defects

4.3.1.1 All castings are to have a workmanlike finish and are to be free from imperfections and defects which would be prejudicial to their proper application in service. Minor casting defects which may still be visible after machining such as small sand and slag inclusions, small cold shuts and scabs are to be trimmed off by the manufacturer in accordance with 4.11.

4.3.2 Removal of defects

4.3.2.1 Casting defects which may impair the service performance of the castings, e.g. major non-metallic inclusions, shrinkage cavities, blow holes and cracks, are not permitted. They may be removed by one of the methods described in 4.11 and repaired within the limits and restrictions for the severity zones. Full description and documentation must be available for the surveyor.

**Table 4.2.1 : Typical chemical composition for steel propeller castings**

| Alloy type | C max. (%) | Mn max. (%) | Cr (%) | Mo 1) max. (%) | Ni (%) |
|---|---|---|---|---|---|
| Martensitic (12 Cr 1 Ni) | 0.15 | 2.0 | 11.5 - 17.0 | 0.5 | Max. 2.0 |
| Martensitic (13 Cr 4 Ni) | 0.06 | 2.0 | 11.5 - 17.0 | 1.0 | 3.5 - 5.0 |
| Martensitic (16 Cr 5 Ni) | 0.06 | 2.0 | 15.0 - 17.5 | 1.5 | 3.5 - 6.0 |
| Austenitic (19 Cr 11 Ni) | 0.12 | 1.6 | 16.0 - 21.0 | 4.0 | 8.0 - 13.0 |

Note 1) Minimum values are to be in accordance with recognised national or international standards

**Table 4.2.2 : Mechanical properties for steel propeller castings**

| Alloy type | Proof stress $R_{p0.2}$ min. [N/mm$^2$] | Tensile strength $R_m$ min. [N/mm$^2$] | Elongation $A_5$ min. (%) | Red. Of area Z min. (%) | Charpy V-notch[1]) Energy min. (J) |
|---|---|---|---|---|---|
| (12 Cr 1 Ni) | 440 | 590 | 15 | 30 | 20 |
| (13 Cr 4 Ni) | 550 | 750 | 15 | 35 | 30 |
| (16 Cr 5 Ni) | 540 | 760 | 15 | 35 | 30 |
| (19 Cr 11 Ni) | 180[2)] | 440 | 30 | 40 | - |

Notes:

1) Not required for general service and the lowest ice class notations. For other ice class notations, tests are to be made -10°C.

2) $R_{p1.0}$ value is 205 [N/mm$^2$].

**4.4 Dimensions, dimensional and geometri-cal tolerances**

4.4.1 The verification of dimensions, the dimensional and geometrical tolerances is the responsibility of the manufacturer. The report on the relevant examinations is to be submitted to the Surveyor, who may require checks to be made in his presence.

4.4.2 Static balancing is to be carried out on all propellers in accordance with the approved

drawing. Dynamic balancing may be necessary for propellers running above 500 rpm.

**4.5 Chemical Composition**

4.5.1 Typical cast steel propeller alloys are grouped into four types depending on their chemical composition as given in Table 4.2.1. Cast steel whose chemical composition deviate from the typical values of Table 4.2.1 must be specially approved by Designated Authority/Classification Society.

4.5.2 The manufacturer is to maintain records of the chemical analyses of the production casts, which are to be made available to the Surveyor so that he can satisfy himself that the chemical composition of each casting is within the specified limits.

**4.6 Heat treatment**

4.6.1 Martensitic castings are to be austenitized and tempered. Austenitic castings should be solution treated.

**4.7. Mechanical properties**

4.7.1 The mechanical properties are to comply with values given in Table 4.2.2. These values refer to the test specimens machined from integrally cast test coupons attached to the hub or on the blade. The thickness of test coupon is to be in accordance with a recognized standard.

4.7.2 Where possible, the test coupons attached on blades are to be located in an area between 0.5 to 0.6R, where R is the radius of the propeller.

4.7.3 The test bars are not to be detached from the casting until the final heat treatment has been carried out. Removal is to be by non-thermal procedures.

4.7.4 Separately cast test bars may be used subject to prior approval of Designated Authority/Classification Society. The test bars are to be cast from the same heat as the castings represented and heat treated with the castings represented.

4.7.5 At least one set of mechanical tests is to be made on material representing each casting in accordance with Ch.2.

4.7.6 As an alternative to 4.7.5, where a number of small propellers of about the same size, and less than 1[m] in diameter, are made from one cast and heat treated in the same furnace charge, a batch testing procedure may be adopted using separately cast test samples of suitable dimensions. At least one set of mechanical tests is to be provided for each multiple of five castings in the batch.

**4.8 Definition of skew, severity zones**

4.8.1 In order to relate the degree of inspection to the criticality of imperfections in propeller blades and to help reduce the risk of failure by fatigue cracking after repair, propeller blades are divided into three severity zones designated

A, B and C. Definition of skew, and, severity zones are given in Ch.8, 3.9.

**4.9 Non-destructive examination**

4.9.1 Qualification of personnel involved in NDT

4.9.1.1 Personnel involved in NDT are to be qualified according to the requirements of Designated Authority/Classification Society.

4.9.2 Visual Testing

4.9.2.1 All finished castings are to be 100% visually inspected by the manufacturer. Castings are to be free from cracks, hot tears or other imperfections which, due to their nature, degree or extent, will interfere with the use of the castings. A general visual examination is to be carried out by the Surveyor.

4.9.3 Liquid penetrant testing

4.9.3.1 Liquid penetrant testing procedure is to be submitted to Designated Authority/Classification Society and is to be in accordance with ISO 3452-1:2013 or a recognized standard. The acceptance criteria are specified in 4.10.

4.9.3.2 For all propellers, separately cast blades and hubs, the surfaces covered by severity zones A, B and C are to be liquid penetrant tested. Testing of zone A is to be undertaken in the presence of the Surveyor, whilst testing of zone B and C may be witnessed by the Surveyor upon his request.

4.9.3.3 If repairs have been made either by grinding or by welding, the repaired areas are additionally to be subjected to the liquid penetrant testing independent of their location and/or severity zone. Weld repairs are, independent of their location, always to be assessed according to zone A.

4.9.4 Magnetic particle testing

4.9.4.1 Magnetic particle testing may be used in lieu of liquid penetrant testing for examination of martensitic stainless steels castings. Magnetic particle testing procedure is to be submitted to Designated Authority/Classification Society and is to be in accordance with ISO 9934-1:2016 or a recognized standard.

4.9.5 Radiographic and ultrasonic testing

4.9.5.1 When required by Designated Authority/Classification Society or when deemed necessary by the manufacturer, further non-destructive testing (e.g. radiographic and/or ultrasonic testing) are to be carried out. The acceptance criteria or applied quality levels are then to be agreed between the manufacturer and Designated Authority/Classification Society in accordance with a recognized standard.

Note: due to the attenuating effect of ultrasound within austenitic steel castings, ultrasonic testing may not be practical in some cases, depending on the shape/type/thickness, and grain-growth direction of the casting.

**4.10 Acceptance criteria for liquid penetrant testing and magnetic particle testing**

4.10.1 Definitions of liquid penetrant indications

4.10.1.1 **Indication:** In the liquid penetrant testing an indication is the presence of detectable bleed-out of the penetrant liquid from the material discontinuities appearing at least 10 minutes after the developer has been applied.

4.10.1.2 **Relevant indication:** only indications which have any dimension greater than 1.5mm shall be considered relevant for the categorization of indications.

4.10.1.3 **Non-linear indication:** an indication with a largest dimension less than three times its smallest dimension (i.e. $l < 3\ w$).

4.10.1.4 **Linear indication:** an indication with a largest dimension three or more times its smallest dimension (i.e. $l \geq 3\ w$).

4.10.1.5 **Aligned indications**:

a) Non-linear indications form an alignment when the distance between indications is less than 2 [mm] and at least three indications are aligned. An alignment of indications is considered to be a unique indication and its length is equal to the overall length of the alignment.

b) Linear indications form an alignment when the distance between two indications is smaller than the length of the longest indication.

Illustration of liquid penetrant indications is given in Fig. 4.10.1.

4.10.2 Acceptance standard

4.10.2.1 The surface to be inspected is to be divided into reference areas of 100 [$cm^2$]. Each reference area may be square or rectangular with the major dimension not exceeding 250 [mm]. The area is to be taken in the most unfavourable location relative to the indication being evaluated.

4.10.2.2 The relevant indications detected with respect to their size and number, are not to exceed the values given in the Table 4.10.1. Areas which are prepared for welding are independent of their location always to be assessed according to zone A. The same applies to the welded areas after being finished machined and/or grinded.

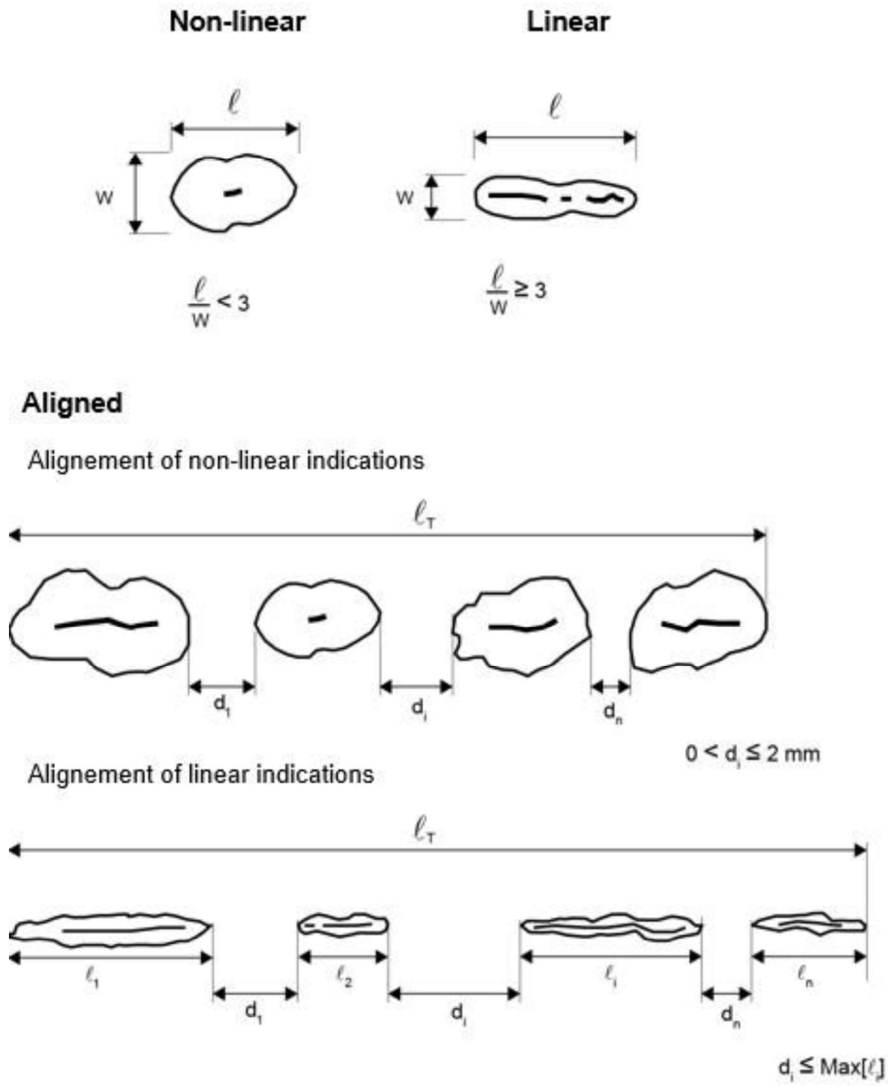



**Fig.4.10.1 : Shape of indications**

**Table 4.10.1 : Allowable number and size of relevant indications in a reference area of 100 cm², depending on severity zones**

| Severity zone | Max. total number of indications | Type of Indication | Max. number for each type[1),2)] | Max. dimension of indication [mm] |
|---|---|---|---|---|
| A | 7 | Non-linear | 5 | 4 |
| | | Linear | 2 | 3 |
| | | Aligned | 2 | 3 |
| B | 14 | Non-linear | 10 | 6 |
| | | Linear | 4 | 6 |
| | | Aligned | 4 | 6 |
| C | 20 | Non-linear | 14 | 8 |
| | | Linear | 6 | 6 |
| | | Aligned | 6 | 6 |

**Table 4.10.1 (Contd.)**

Notes:

1) Single non-linear indications less than 2 [mm] in Zone A and less than 3 [mm] for the other zones are not considered relevant.
2) The total number of non-linear indications may be increased to the maximum total number, or part thereof, represented by the absence of linear or aligned indications.

**4.11 Repair of defects**

4.11.1 Defective castings are to be repaired in accordance with the requirements given in 4.11.2 to 4.11.7 and, where applicable, the requirements of 4.12.

4.11.2 In general the repairs are to be carried out by mechanical means, e.g. by grinding, chipping or milling. The resulting grooves are to be blended into the surrounding surface so as to avoid any sharp contours. Complete elimination of the defective material is to be verified by liquid penetrant testing, or magnetic particle testing, if applicable.

4.11.3 Weld repairs are to be undertaken only when they are considered to be necessary and have prior approval of the Surveyor.

4.11.4 The excavations are to be suitably shaped to allow good access for welding. The resulting grooves are to be subsequently ground smooth and complete elimination of the defective material is to be verified by liquid penetrant testing. Welds having an area less than 5 [$cm^2$] are to be avoided.

4.11.5 Grinding in severity Zone A may be carried out to an extent that maintains the blade thickness. Repair welding is generally not permitted in severity Zone A and will only be allowed after special consideration.

4.11.6 Defects in severity Zone B that are not deeper than t/40 [mm] ("t" is the minimum local thickness according to the Rules) or 2 [mm], whichever is greatest, are to be removed by grinding. Those defects that are deeper may be repaired by welding subject to prior approval from Designated Authority/Classification Society.

4.11.7 Repair welding is generally permitted in severity Zone C.

4.11.8 Repair documentation

4.11.8.1 The foundry is to maintain records of inspections, welding, and any subsequent heat treatment, traceable to each casting. Before welding is started, full details of the extent and location of the repair, the proposed welding procedure, heat treatment and subsequent inspection procedures are to be submitted to the Designated Authority/Classification Society for approval.

**4.12 Welding repair procedure**

4.12.1 Before welding is started, manufacturer is to submit to Designated Authority/Classification Society a detailed welding procedure specification covering the weld preparation, welding positions, welding parameters, welding consumables, preheating, post weld heat treatment and inspection procedures.

4.12.2 All weld repairs are to be carried out in accordance with qualified procedures, and by welders who are qualified to a recognized standard. Welding Procedure Qualification Tests are to be carried out in accordance with 4.15 and witnessed by the Surveyor. Defects to be repaired by welding are to be ground to sound material according to 4.10. The welding grooves are to be prepared in such a manner which will allow a good fusion of the groove bottom. The resulting ground areas are to be examined in the presence of the Surveyor by liquid penetrant testing in order to verify the complete elimination of defective material.

4.12.3 Welding is to be done under controlled conditions free from draughts and adverse weather.

4.12.4 Metal arc welding with electrodes or filler wire used in the procedure tests is to be used. The welding consumables are to be stored and handled in accordance with the manufacturer's recommendations.

4.12.5 Slag, undercuts and other imperfections are to be removed before depositing the next run.

4.12.6 The martenistic steels are to be furnace re-tempered after weld repair. Subject to prior approval, however, local stress relieving may be considered for minor repairs.

4.12.7 On completion of heat treatment the weld repairs and adjacent material are to be ground smooth. All weld repairs are to be liquid penetrant tested.

**4.13 Identification and marking**

4.13.1 The manufacturer is to adopt a system for the identification of all castings, which enable the material to be traced to its original cast. The Surveyor is to be given full facilities for so tracing the castings when required. Each finished casting propeller is to be marked by the manufacturer at least with the following particulars:

a) Heat number or other marking which will enable the full history of the casting to be traced;

b) Grade of cast material or corresponding abbreviated designation

c) The Designated Authority/Classification Society certificate number and abbreviated name of local Designated Authority/Classification Society office;

d) Ice class symbol, where applicable;

e) Skew angle for high skew propellers;

f) Date of final inspection.

4.13.2 The designated stamp is to be put on when the casting has been accepted.

**4.14 Document and Certification**

4.14.1 The manufacturer is to provide the Surveyor with an inspection certificate giving the following particulars for each casting which has been accepted:

a) Purchaser's name and order number;

b) Vessel identification, where known;

c) Description of the casting with drawing number;

d) Diameter, number of blades, pitch, direction of turning;

e) Skew angle for high skew propellers;

f) Final weight;

g) Alloy type, heat number and chemical composition;

h) Casting identification number;

i) Details of time and temperature of heat treatment;

j) Results of the mechanical tests.

k) Results of non-destructive tests and details of test procedure where applicable.

**4.15 Welding procedure qualification test for repair of cast steel propeller**

4.15.1 General

4.15.1.1 This sub-section provides requirements for qualification tests of welding procedures intended for the repair of cast steel propellers.

4.15.1.2 For the welding procedure approval the welding procedure qualification tests are to be carried out with satisfactory results. The qualification tests are to be carried out with the same welding process, filler metal, preheating and stress-relieving treatment as those intended applied by the actual repair work. Welding procedure specification is to refer to the test results achieved during welding procedure qualification testing.

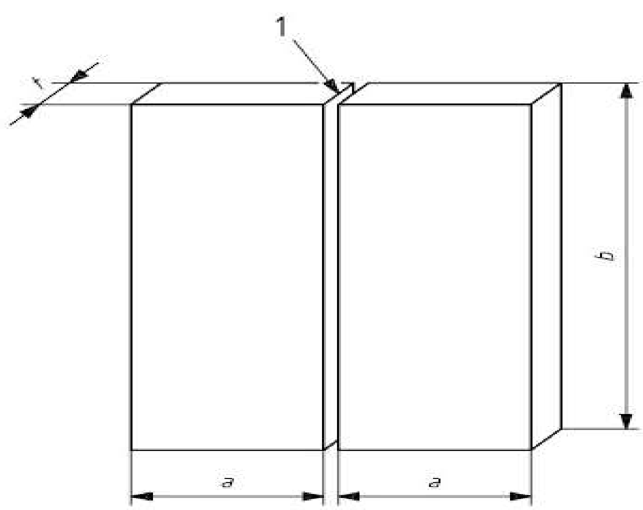
4.15.1.3 Welding procedures qualified at a manufacturer are valid for welding in workshops under the same technical and quality management.

4.15.2 Test piece and welding of sample

4.15.2.1 The test assembly, consisting of cast samples, is to be of a size sufficient to ensure a reasonable heat distribution and according to Fig. 4.15.2.1 with the minimum dimensions. The dimensions and shape of the groove is to be representative of the actual repair work.

4.15.2.2 Preparation and welding of test pieces are to be carried out in accordance with the general condition of repair welding work which it represents.

4.15.2.3 Welding of the test assemblies and testing of test specimens are to be witnessed by the Surveyor.




1: Joint preparation and fit-up as detailed in the preliminary Welding

Procedure Specification

a: minimum value 150mm

b: minimum value 350mm

t: material thickness

**Fig.4.15.2.1 : Test piece for welding repair procedure**

4.15.3 Examinations and tests

4.15.3.1 Test assembly is to be examined non-destructively and destructively in accordance with Table 4.15.3.1 and Fig. 4.15.3.1.

4.15.3.2 Non-destructive testing

.1 Test assembly is to be examined by visual and liquid penetrant testing, or magnetic particle testing if applicable, prior to the cutting of test specimen. In case, that any post-weld heat treatment is required or specified, non-destructive testing is to be performed after heat treatment. No cracks are permitted. Imperfections detected by liquid penetrant testing, or magnetic particle testing if applicable, are to be assessed in accordance with 4.10.

4.15.3.3 Tensile test

.1 Two flat transverse tensile test specimens are be prepared. Testing procedures are to be in accordance with Ch.2. Alternatively tensile test specimens according to recognized standards acceptable to Designated Authority/Classification Society may be used. The tensile strength is to meet the specified minimum value of the base material. The location of fracture is to be reported, i.e. weld metal, HAZ or base material.

4.15.3.4 Bend test

.1 Transverse bend tests for butt joints are to be in accordance with Ch.2, or, according to a recognized standard. The mandrel diameter shall be 4 x thickness except for austenitic steels, in which case the mandrel diameter is to be 3 x thickness. The bending angle is to be 180°. After testing, the test specimens are not to reveal any open defects in any direction greater than 3 [mm]. Defects appearing at the corners of a test specimen during testing are to be investigated case by case. Two root and two face bend specimens are to be tested. For thickness 12 [mm] and over, four side bend specimens may alternatively be tested.

4.15.3.5 Macro-examination

.1 Two macro-sections are to be prepared and etched on one side to clearly reveal the weld metal, the fusion line, and the heat affected zone. Cracks and lack of fusion are not permitted. Imperfections such as slag inclusions, and pores greater than 3 [mm] are not permitted.

4.15.3.6 Impact test

.1 Impact test is required, where the base material is impact tested. Charpy V-notch test specimens are to be in accordance with Ch.2. Two sets are to be taken, one set with the notch positioned in the center of the weld and one set with the notch positioned in the HAZ (i.e. the mid-point of the notch is to be at 1 [mm] to 2 [mm] from the fusion line), respectively. The test temperature, and impact energy are to comply with the requirement specified for the base material.

4.15.3.7 Hardness test

.1 The macro-section representing the start of welding is to be used for HV 10 hardness testing. Indentations are to traverse 2 [mm] below the surface. At least three individual indentations are to be made in the weld metal, the HAZ (both sides) and in the base metal (both sides). The values are to be reported for information.

4.15.3.8 Re-testing

.1 If the test piece fails to comply with any of the requirements for visual or non-destructive testing one further test piece is to be welded and

subjected to the same examination. If this additional test piece does not comply with the relevant requirements, the pWPS (preliminary welding procedure specification) is to be regarded as not capable of complying with the requirements without modification.

.2 If any test specimens fail to comply with the relevant requirements for destructive testing due to weld imperfections only, two further test specimens are to be obtained for each one that failed. These specimens can be taken from the same test piece if there is sufficient material available or from a new test piece, and are to be subjected to the same test. If either of these additional test specimens does not comply with the relevant requirements, the pWPS is to be regarded as not capable of complying with the requirements without modification.

.3 If a tensile test specimen fails to meet the requirements, the re-testing is to be in accordance with Ch.2.

.4 If there is a single hardness value above the maximum values allowed, additional hardness tests are to be carried out (on the reverse of the specimen or after sufficient grinding of the tested surface). None of the additional hardness values is to exceed the maximum hardness values required.

.5 The re-testing of Charpy impact specimens are to be carried out in accordance with Ch.2.

.6 Where there is insufficient welded assembly remaining to provide additional test specimens, a further assembly is to be welded using the same procedure to provide the additional specimens.

| Table 4.15.3.1 Type of tests and extent of testing | |
|---|---|
| **Type of test** | **Extent of testing** |
| Visual testing | 100% as per 4.15.3.2 |
| Liquid penetrant testing (1) | 100% as per 4.15.3.2 |
| Transverse tensile test | Two specimens as per 4.15.3.3 |
| Bend test (2) | Two root and two face specimens as per 4.15.3.4 |
| Macro examination | Three specimens as per 4.15.3.5 |
| Impact test | Two sets of three specimens as per 4.15.3.6 |
| Hardness test | As per 4.15.3.7 |
| (1) Magnetic particle testing may be used in lieu of liquid penetrant testing for martensitic stainless steels. (2) For t≥12mm, the face and root bend may be substituted by 4 side bend test specimens. | |

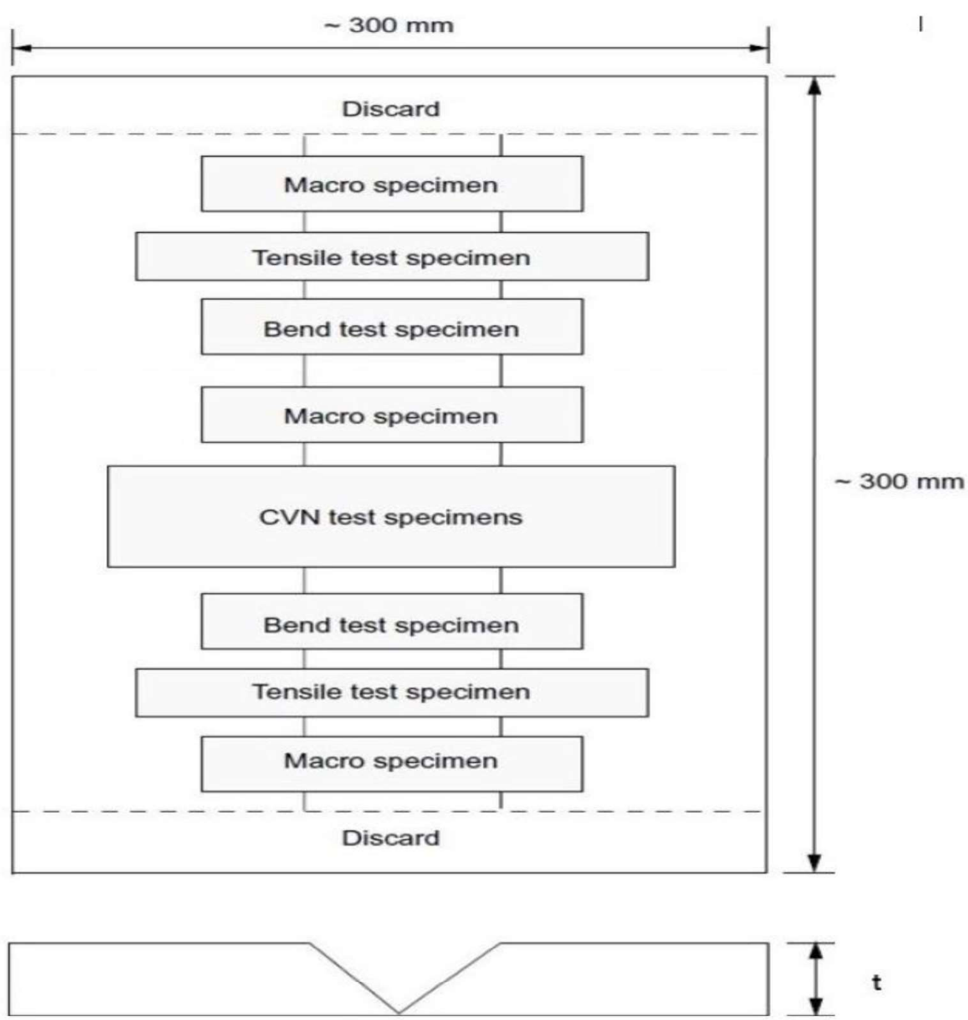



**Fig.4.15.3.1 : Weld test assembly**

4.15.4 Test record

4.15.4.1 Welding conditions for test assemblies and test results are to be recorded in welding procedure qualification. Forms of welding procedure qualification records may be in accordance with recognised standards.

4.15.4.2 A statement of the results of assessing each test piece, including repeat tests, is to be made for each welding procedure qualification records. The relevant items listed for the WPS are to be included.

4.15.4.3 The welding procedure qualification record is to be signed by the Surveyor witnessing the test and is to include IR identification.

4.15.5 Range of approval

4.15.5.1 General

.1 All the conditions of validity stated below are to be met independently of each other. Changes outside of the ranges specified are to require a new welding procedure test. A qualification of a WPS obtained by a manufacturer is valid for welding in workshops or sites under the same technical and quality control of that manufacturer.

4.15.5.2 Base metal

.1 Range of approval for steel cast propeller is limited to steel grade tested.

4.15.5.3 Thickness

.1 The qualification of a WPS carried out on a weld assembly of thickness t is valid for the thickness range given in Table 4.15.5.3.

**Table 4.15.5.3 Range of qualification for thickness**

| Thickness of the test piece, t (mm) | Range of approval |
|---|---|
| 15<t≤30 | 3mm to 2t |
| t>30 | 0.5t to 2t or 200mm, whichever is the greater |

4.15.5.4 Welding position

.1 Approval for a test made in any position is restricted to that position.

4.15.5.5 Welding process

.1 The approval is only valid for the welding process used in the welding procedure test. Single run is not qualified by multi-run butt weld test used in this Section.

4.15.5.6 Filler metal

.1 The approval is only valid for the filler metal used in the welding procedure test.

4.15.5.7 Heat input

.1 The upper limit of heat input approved is 15% greater than that used in welding the test piece. The lower limit of heat input approved is 15% lower than that used in welding the test piece.

4.15.5.8 Preheating and interpass temperature

.1 The minimum preheating temperature is not to be less than that used in the qualification test. The maximum interpass temperature is not to be higher than that used in the qualification test.

4.15.5.9 Post-weld heat treatment

.1 The heat treatment used in the qualification test is to be specified in pWPS. Holding time may be adjusted as a function of thickness.

## Section 5

## Austenitic Stainless Steel Castings

### 5.1 Scope

5.1.1 This section gives the requirements for castings in austenitic stainless steels for piping systems in ships for liquefied gases where the design temperature is not lower than –165°C and in bulk chemical carriers.

5.1.2 Where it is proposed to use alternative steels, particulars of the specified chemical composition, mechanical properties and heat treatment are to be submitted for approval.

### 5.2 Chemical composition

5.2.1 The chemical composition of ladle samples is to comply with the requirements given in Table 5.2.1.

**Table 5.2.1 : Chemical composition of austenitic stainless steel castings**

| Type of steel | Chemical composition % | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | C max. | Si | Mn | S | P | Cr | Mo | Ni | Others |
| 304L | 0.03 | 0.20-1.5 | 0.50-2.0 | 0.40 max. | | 17.0- | - | 8.0-12.0 | - |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 304 | 0.08 | | | | 21.0 | - | 8.0-12.0 | - |
| 316L | 0.03 | | | | | 2.0-3.0 | 9.0-13.0 | - |
| 316 | 0.08 | | | | | 2.0-3.0 | 9.0-13.0 | - |
| 317 | 0.08 | | | | | 3.0-4.0 | 9.0-12.0 | - |
| 347 (see Note) | 0.06 | | | | | - | 9.0-12.0 | Nb ≥8xC≤0.90 |
| Note: When guaranteed impact values at low temperature are not required, the maximum carbon content may be 0.08% and the maximum niobium may be 1.00%. | | | | | | | | |

### 5.3 Heat treatment

5.3.1 All castings are to be solution treated at a temperature of not less than 1000°C and cooled rapidly in air, oil or water.

### 5.4 Mechanical tests

5.4.1 One tensile test specimen is to be prepared from material representing each casting or batch of castings. In addition, where the castings are intended for liquefied gas applications, where the design temperature is lower than –55°C, one set of three Charpy V-notch impact test specimens is to be prepared.

5.4.2 The tensile test is to be carried out at ambient temperature and the results are to comply with the requirements given in Table 5.4.2.

5.4.3 The average value for impact test specimens is to comply with the appropriate requirements given in Table 5.4.2. One individual value may be less than the required average value provided that it is not less than 70 percent of this average value. See Ch.1, 1.10 for re-test procedures.

**Table 5.4.2 : Mechanical properties for acceptance purposes : austenitic stainless steel castings**

| Type of steel | Tensile strength [N/mm$^2$] minimum | 1.0% proof stress [N/mm$^2$] minimum | Elongation on 5.65 $\sqrt{S_0}$ % minimum | Reduction of area % minimum | Charpy V-notch impact tests | |
|---|---|---|---|---|---|---|
| | | | | | Test temp. °C | Average energy J minimum |
| 304L | 430 | 215 | 26 | 40 | -196 | 41 |
| 304 | 480 | 220 | | | | |
| 316L | 430 | 215 | 26 | 40 | -196 | 41 |
| 317 | 480 | 240 | | | | |
| 347 | 480 | 215 | 22 | 35 | -196 | 41 |

### 5.5 Intergranular corrosion tests

5.5.1 Where corrosive conditions are anticipated in service, intergranular corrosion tests are required on castings in grades 304, 316 and 317. Such tests may not be required for grades 304L, 316L and 347.

5.5.2 Where an intergranular corrosion test is specified, it is to be carried out in accordance with the standard referred in 9.6.2 of Chapter 3.

### 5.6 Non-destructive examination

5.6.1 The non-destructive examination of castings is to be carried out in accordance with the appropriate requirements of Designated Authority/Classification Society and as agreed between the manufacturer, purchaser and Surveyor.

## Section 6

## Castings for other Applications

### 6.1 General

6.1.1 Details of chemical composition, heat treatment, mechanical properties of steel castings for crankshafts and those intended for elevated temperature service are to be submitted for approval of Designated Authority/Classification Society.

# Chapter 5

# Steel Forgings

***Contents***



## Section 1

## General Requirements

### 1.1 Scope

1.1.1 All important steel forgings, as defined in the relevant construction Rules, are to be manufactured and tested in accordance with the requirements of this Chapter.

1.1.2 Where required by the relevant Rules dealing with design and construction, forgings are to be manufactured and tested in accordance with Ch.1 and 2, together with the general requirements given in this Chapter.

1.1.3 Alternatively, forgings which comply with National or proprietary specifications may be accepted provided such specifications give reasonable equivalence to these requirements or are otherwise specially approved for a specific application by Designated Authority/Classification Society.

### 1.2 Manufacture

1.2.1 Forgings are to be made at the works approved by Designated Authority/Classification Society. Also refer Chapter 1, Section 1, Cl. 1.3.2.

1.2.2 The steel used in the manufacture of forgings is to be made by a process approved by Designated Authority/Classification Society.

1.2.3 Adequate top and bottom discards are to be made to ensure freedom from piping and harmful segregations in the finished forgings.

1.2.4 The plastic deformation is to be such as to ensure soundness, uniformity of structure and satisfactory mechanical properties after heat treatment. The reduction ratio is to be in accordance with the following Table:

| **Method of manufacture** | **Total reduction ratio**<br>**(See Notes 1, 2 & 3)** |
|---|---|
| | |
| Made directly from ingots or forged blooms or billets | 3:1 where L > D<br>1.5:1 where L ≤ D |
| Made from rolled products | 4:1 where L > D<br>2:1 where L ≤ D |
| Notes<br>1 L and D are the length and diameter respectively of the part of the forging under consideration. | |
| 2 the reduction ratio is to be calculated with reference to the average cross-sectional area of the ingot. Where an ingot is initially upset, this reference area may be taken as the average cross-sectional area after this operation. | |
| 3 For rolled bars used as a substitute for forgings (see 1.1.1) the reduction ratio is not to be less than 6 : 1 | |
| 4 For forgings made by upsetting, the length after upsetting is to be not more than one-third of the length before upsetting or, in the case of an initial forging reduction of at least 1.5:1, not more than one half of the length before upsetting. | |

1.2.5 For crankshafts, where grain flow is required in the most favourable direction having regard to the mode of stressing in service, the proposed method of manufacture may required special approval by Designated Authority/Classification Society. In such cases, tests may be required to demonstrate that a satisfactory structure and grain flow are obtained.

1.2.6 The shaping of forgings or rolled slabs and billets by flame cutting, scarfing or arc-air gouging is to be undertaken in accordance with recognized good

practice and unless otherwise approved, is to be carried out before the final heat treatment. Preheating is to be employed when necessitated by the composition and/or thickness of the steel.

1.2.7 For certain components, subsequent machining of all flame cut surfaces may be required.

1.2.8 When two or more forgings are joined by welding to form a composite component the proposed welding procedure specification is to be submitted for approval. Welding procedure qualification tests may be required.

**1.3 Quality of forgings**

1.3.1 All forgings are to be free from surface or internal defects which would be prejudicial to their proper application in service.

**1.4 Chemical composition**

1.4.1 All forgings are to be made from killed steel, and the chemical composition is to be appropriate for the type of steel, dimensions and required mechanical properties of the forgings being manufactured.

1.4.2 The chemical composition of each heat is to be determined by the manufacturer on a sample taken preferably during the pouring of the heat. When multiple heats are tapped into a common ladle, the ladle analysis is applicable.

**1.5 Heat treatment (including surface hardening and straightening)**

1.5.1 At an appropriate stage of manufacture, after completion of all hot working operations, forgings are to be suitably heat treated to refine the grain structure and to obtain the required mechanical properties. Heat treatment is to be carried out in properly constructed furnaces which are efficiently maintained and have adequate means for control and recording of temperature. The furnace dimensions are to be such as to allow the whole furnace charge to be uniformly heated to the necessary temperature. In the case of very large forgings alternative methods of heat treatment will be specially considered by Designated Authority/Classification Society.

1.5.2 Except as provided in 1.5.7 and 1.5.8 forgings are to be supplied in one of the following conditions:

a) Carbon and carbon-manganese steels

   Fully annealed

   Normalized

   Normalized and tempered

   Quenched and tempered

b) Alloy steels

   Quenched and tempered

For all types of steel the tempering temperature is not less than 550°C. Where forgings for gearing are not intended for surface hardening tempering at lower temperature may be allowed.

1.5.3 Alternatively, alloy steel forgings may be supplied in the normalized and tempered condition, in which case the specified mechanical properties are to be agreed with Designated Authority Classification Society.

Sufficient thermocouples are to be connected to the furnace charge to measure and record that its temperature is adequately uniform unless the temperature uniformity of the furnace is verified at regular intervals.

1.5.4 If for any reasons a forging is subsequently heated for further hot working the forging is to be re-heat treated.

1.5.5 If any straightening operation is performed after the final heat treatment, a subsequent stress relieving heat treatment to avoid harmful residual stresses is to be carried out, unless otherwise agreed.

1.5.6 Where it is intended to surface harden forgings, full details of the proposed procedure and specification are to be submitted for the approval of Designated Authority/Classification Society. For the purpose of this approval, the manufacturer may be required to demonstrate by test that the proposed procedure gives a uniform surface layer of the required hardness and depth and that it does not impair the soundness and properties of the steel.

1.5.7 Where induction hardening or nitriding is to be carried out after machining, forgings are to be heat treated at an appropriate stage to a condition suitable for this subsequent surface hardening.

1.5.8 Where carburizing is to be carried out after machining, forgings are to be heat treated at an appropriate stage (generally either by full annealing or by normalising and tempering) to a condition suitable for subsequent machining and carburizing.

1.5.9 If a forging is locally reheated or any straightening operation is performed after the final heat treatment, consideration is to be given to a subsequent stress relieving heat treatment.

1.5.10 The manufacturer is to maintain records of heat treatment identifying the furnace used, furnace charge, date, temperature and time at the beginning and end of heat treatment cycle. The records are to be presented to the Surveyor on request.

**1.6 Mechanical tests**

1.6.1 The requirements of Mechanical tests and mechanical properties are given in Section 2 and 3.

**1.7 Inspection**

1.7.1 Before acceptance, all forgings are to be presented to the Surveyors for visual examination. Where applicable, this is to include the examination of internal surfaces and bores. Unless otherwise agreed, the verification of the dimensions is the responsibility of the manufacturer.

1.7.2 When required by the relevant construction Rules, or by the approved procedure for welded

composite components appropriate non-destructive testing is also to be carried out before acceptance and the results are to be reported by the manufacturer.

The forgings to be examined in accordance with the requirements of the Designated Authority/Classification Society.

1.7.3 When required by the conditions of approval for surface hardened forgings, (1.5.6) additional test samples are to be processed at the same time as the forgings which they represent. These test samples are subsequently to be sectioned in order to determine the hardness, shape and depth of the locally hardened zone and which are to comply with the requirements of the approved specification.

1.7.4 In the event of any forging proving defective during subsequent machining or testing, it is to be rejected notwithstanding any previous certification.

**1.8 Rectification of defective forgings**

1.8.1 Defects may be removed by grinding or chipping and grinding provided the component dimensions are acceptable.

The resulting grooves are to have a bottom radius of approximately three times the groove depth and are to be blended into the surrounding surface so as to avoid any sharp contours. Complete elimination of the defective material is to be verified by magnetic particle testing or liquid penetrant testing.

1.8.2 Repair welding of crankshaft forgings is not permitted. In the case of other forgings repair welding may be allowed subject to prior approval of Designated Authority/Classification Society. In such cases, full details of the extent and location of the repair, the proposed welding procedure, heat treatment and subsequent inspection procedures are to be submitted for the approval.

1.8.3 The forging manufacturer is to maintain records of repairs and subsequent inspections traceable to each forging repaired. The records are to be presented to the Surveyor on request.

a) Purchaser's name and order number;

b) Description of forgings and steel quality identification number;

c) Steel making process, cast number and chemical analysis of ladle sample;

d) Results of mechanical tests;

e) General details of heat treatment;

f) Identification number.

**1.9 Identification of forgings**

1.9.1 Before acceptance, all forgings, which have been tested and inspected with satisfactory results, are to be clearly marked in at least one place with the Designated Authority/Classification Society brand and the following particulars:

a) The manufacturer's name or trade mark;

b) Identification mark for the grade of steel;

c) Identification number and/or initials which enable the full history of the forging to be traced;

d) Personal stamp of Surveyor responsible for inspection;

e) Test pressure, where applicable;

f) Date of final inspection;

g) The ' Designated Authority/Classification Society ' name;

h) Abbreviated name of Designated Authority/Classification Society local office.

1.9.2 Where small forgings are manufactured in large numbers, modified arrangements for identification may be specially agreed with Designated Authority/Classification Society.

**1.10 Certification**

1.10.1 The manufacturer is to provide the Surveyor, in duplicate, with a test certificate or shipping statement giving the following particulars for each forging or batch of forgings which has been accepted:

a) Purchaser's name and order number;

b) Description of forgings and steel quality identification number;

c) Steel making process, cast number and chemical analysis of ladle sample;

d) Results of mechanical tests;

e) General details of heat treatment;

f) Identification number.

## Section 2

## Hull and Machinery Steel Forgings for General Applications

**2.1 Scope**

2.1.1 The requirements given in this section are applicable to steel forgings intended for hull and machinery applications such as rudder stocks, pintles, propeller shafts, crankshafts, connecting rods, piston rods, gearing etc. Where relevant, these requirements are also applicable to material for forging stock and to rolled bars intended to be machined into components of simple shape.

2.1.2 These requirements are applicable only to steel forgings where the design and acceptance tests relate to mechanical properties at ambient temperature. For other applications, additional requirements may be necessary especially when the forgings are intended for service at low or elevated temperatures.

**2.2 Chemical Composition**

2.2.1 The chemical composition is to comply with the overall limits given in Tables 2.2.1 and Table 2.2.2 or, where applicable, the requirements of the approved specification.

2.2.2 At the option of the manufacturer, suitable grain refining elements such as aluminium, niobium or vanadium may be added. The content of such elements is to be reported.

2.2.3 Elements designated as residual elements in the individual specifications are not to be intentionally added to the steel. The content of such elements is to be reported.

**Table 2.2.1 : Chemical composition limits [1] for hull steel forgings [6]**

| Steel type | C | Si | Mn | P | S | Cr | Mo | Ni | Cu [4] | Total residuals |
|---|---|---|---|---|---|---|---|---|---|---|
| C, C-Mn | 0.23 [2), 3)] | 0.45 | 0.20-1.50 | 0.035 | 0.035 | 0.30 [4] | 0.15 [4] | 0.40 [4] | 0.30 | 0.85 |
| Alloy | [5] | 0.45 | [5] | 0.035 | 0.035 | [5] | [5] | [5] | 0.30 | - |

1) Composition in percentage mass by mass maximum unless shown as a range.

2) The carbon content may be increased above this level provided that the carbon equivalent (Ceq) is not more than 0.41%, calculated using the following formula:

$$Ceq = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} (\%)$$

3) The carbon content of C and C-Mn steel forgings not intended for welded construction may be 0.65 maximum.

4) Elements are considered as residual elements.

5) Specification is to be submitted for approval.

6) Rudder stocks and pintles should be of weldable quality.

**Table 2.2.2 : Chemical composition limits [1] for machinery steel forgings**

| Steel type | C | Si | Mn | P | S | Cr | Mo | Ni | Cu [3] | Total residuals |
|---|---|---|---|---|---|---|---|---|---|---|
| C, C-Mn | 0.65 [2] | 0.45 | 0.30-1.50 | 0.035 | 0.035 | 0.30 [3] | 0.15 [3] | 0.40 [3] | 0.30 | 0.85 |
| Alloy [4] | 0.45 | 0.45 | 0.30-1.00 | 0.035 | 0.035 | Min 0.40 [5] | Min 0.15 [5] | Min 0.40 [5] | 0.30 | - |

1) Composition in percentage mass by mass maximum unless shown as a range or as a minimum.

2) The carbon content of C and C-Mn steel forgings intended for welded construction is to be 0.23 maximum. The carbon content may be increased above this level provided that the carbon equivalent (Ceq) is not more than 0.41%.

3) Elements are considered as residual elements unless shown as a minimum.

4) Where alloy steel forgings are intended for welded constructions, the proposed chemical composition is subject

to approval by Designated Authority/Classification Society.

[5] One or more of the elements is to comply with the minimum content.

**2.3 Mechanical tests**

2.3.1 Adequate number of test coupons are to be provided for carrying out tests including for retest purposes, with a cross-sectional area of not less than that part of the forging which it represents. This test material is to be integral with each forging except as provided in 2.3.7 and 2.3.10. Where batch testing is permitted according to 2.3.10 the test material may alternatively be a production part or separately forged. Separately forged test material is to have a reduction ratio similar to that used for the forgings represented.

2.3.2 For the purpose of these requirements a set of tests is to consist of one tensile test specimen and when required in other sections of Rules three Charpy V-notch impact test specimens.

2.3.3 Test specimens are normally to be cut with their axes either parallel (longitudinal test) or tangential (tangential test) to the principal axial direction of each product.

2.3.4 Unless otherwise agreed, the longitudinal axis of test specimens is to be positioned as follows:

a) for thickness or diameter upto maximum 50 [mm], the axis is to be at the mid-thickness or the center of the cross section.

b) for thickness or diameter greater than 50 [mm], the axis is to be at one quarter thickness (mid-radius) or 8- [mm], whichever is less, below any heat treated surface.

2.3.5 Except as provided in 2.3.10 the number and direction of tests is to be as follows:

a) Hull components such as rudder stocks, pintles etc. General machinery components such as shafting, connecting rods, etc.

One set of tests is to be taken from the end of each forging in a longitudinal direction except that, at the discretion of the manufacture the alternative directions or positions as shown in Fig.2.3.5a, Fig.2.3.5b and Fig.2.3.5c may be used. Where a forging exceeds both 4 tonnes in mass and 3 [m] in length one set of tests is to be taken from each end. These limits refer to the 'as forged' mass and length but excluding the test material.

b) Pinions - Where the finished machined diameter of the toothed portion exceeds 200 [mm] one set of tests is to be taken from each forging in a tangential direction adjacent to the toothed portion (test position B in Fig.2.3.5d). Where the dimensions preclude the preparation of tests from this position, tests in a tangential direction are to be taken from the end of the journal (test position C in Fig.2.3.5d). If however, the journal diameter is 200 [mm] or less the tests are to be taken in a longitudinal direction (test position A in Fig.2.3.5d). Where the finished length of the toothed portion exceed 1.25 [m], one set of tests is to be taken from each end.

c) Small pinions - Where the finished diameter of the toothed portion is 200 [mm] or less one set of tests is to be taken in a longitudinal direction (test position A in Fig.2.3.5d).

d) Gear wheels - One set of tests is to be taken from each forging in tangential direction (test position A or B in Fig.2.3.5e).

e) Gear wheel rims (made by expanding)

One set of tests is to be taken from each forging in a tangential direction (test position A or B in Fig.2.3.5.f). Where the finished diameter exceeds 2.5 [m] or the mass (as heat treated excluding test material) exceeds 3 tonnes, two sets of tests are to be taken from diametrically opposite positions (test positions A and B in Fig. 2.3.5f). The mechanical properties for longitudinal test are also to be applied.

f) Pinion sleeves - One set of tests is to be taken from each forging in tangential direction (test position A or B in Fig.2.3.5g). Where the finished length exceeds 1.25 [m] one set of tests is to be taken from each end.

g) Crankwebs

One set of tests is to be taken from each forging in a tangential direction.

h) Solid open die forged crankshafts

One set of tests is to be taken in a longitudinal direction from the driving shaft end of each forging (test position A in Fig.2.3.5h).

Where the mass (as heat treated but excluding test material) exceeds 3 tonnes tests in a longitudinal direction are to be taken from each end (test positions A and B in Fig.2.3.5h). Where, however, the crankthrows are formed by machining or flame cutting, the second set of tests is to be taken in a tangential direction from material removed from the crankthrow at the end opposite the driving shaft end (test position C in Fig.2.3.5h).

2.3.6 For closed die crankshaft forgings and crankshaft forgings where the method of manufacture has been specially approved in accordance with 1.2.5, the number and position of test specimens is to be agreed with Designated Authority/Classification Society having regard to the method of manufacture employed.

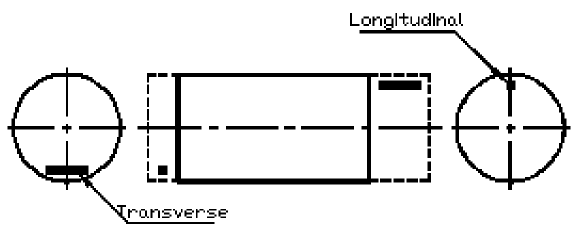



**Fig.2.3.5a : Plain Shaft**

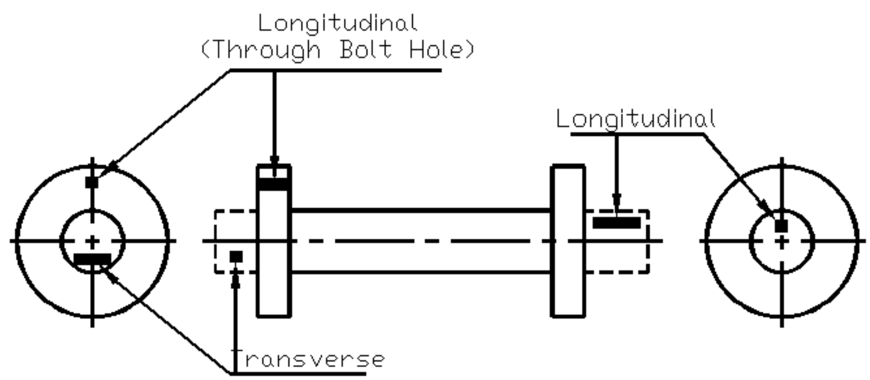



**Fig. 2.3.5b : Flanged Shaft**

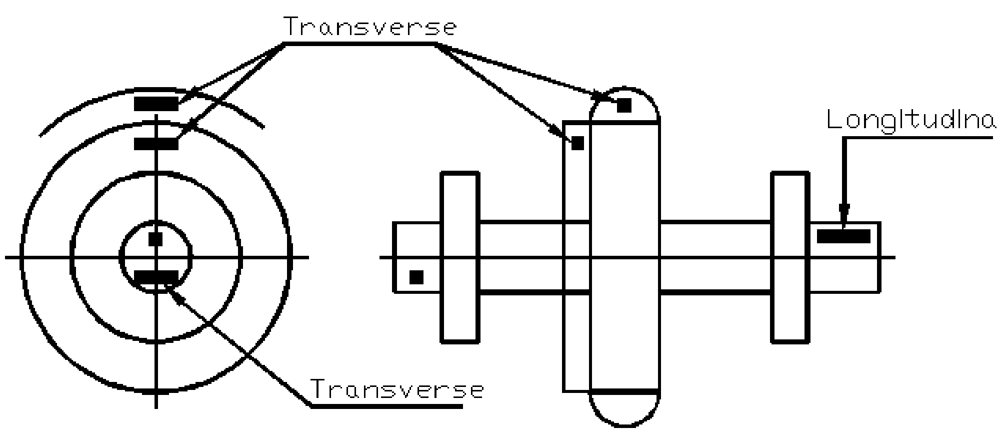



**Fig.2.3.5c : Flanged shaft with collar**

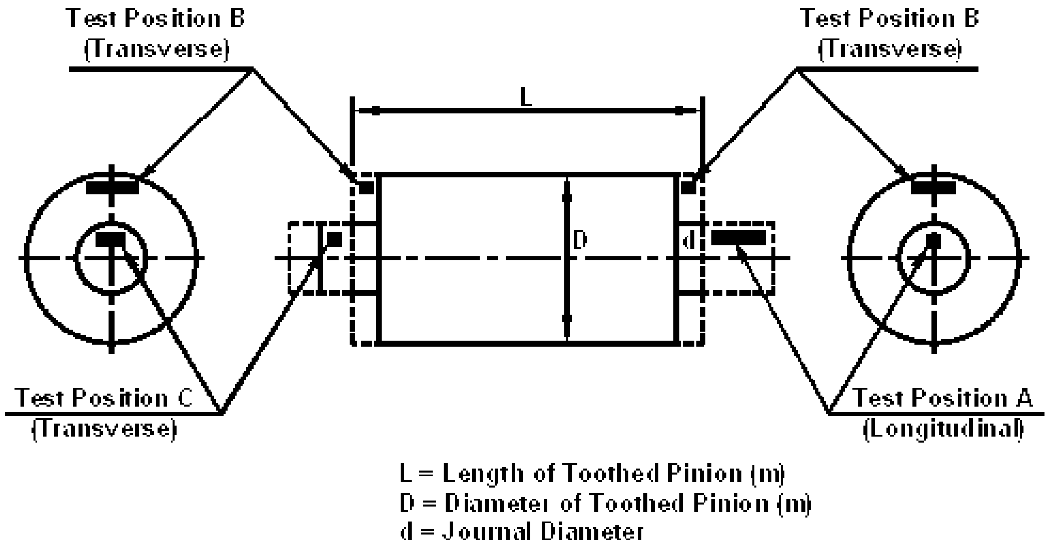



Fig.2.3.5d : Pinion

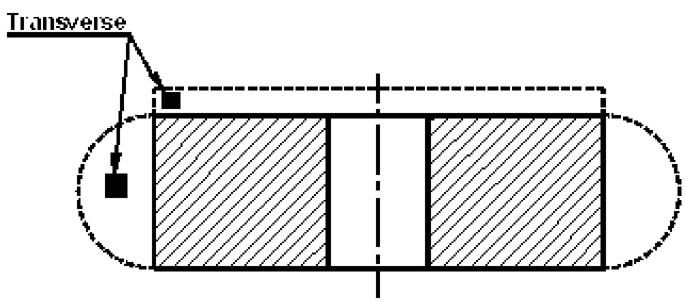



Fig.2.3.5e : Gear wheel

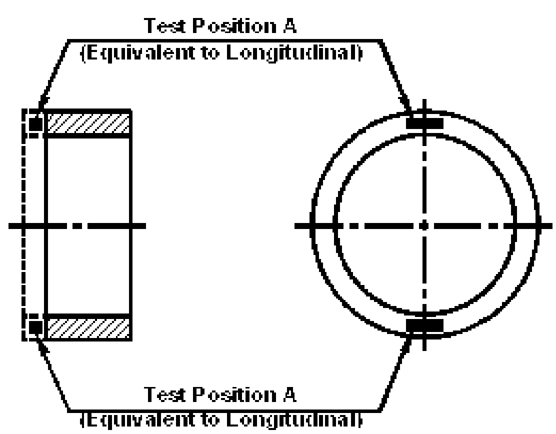



Fig.2.3.5f : Gear rim (made by expanding)

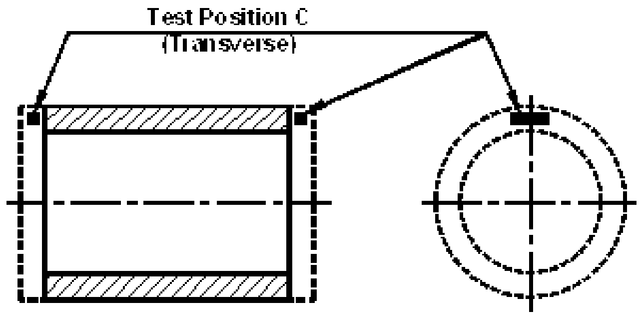



Fig.2.3.5g : Pinion sleeve

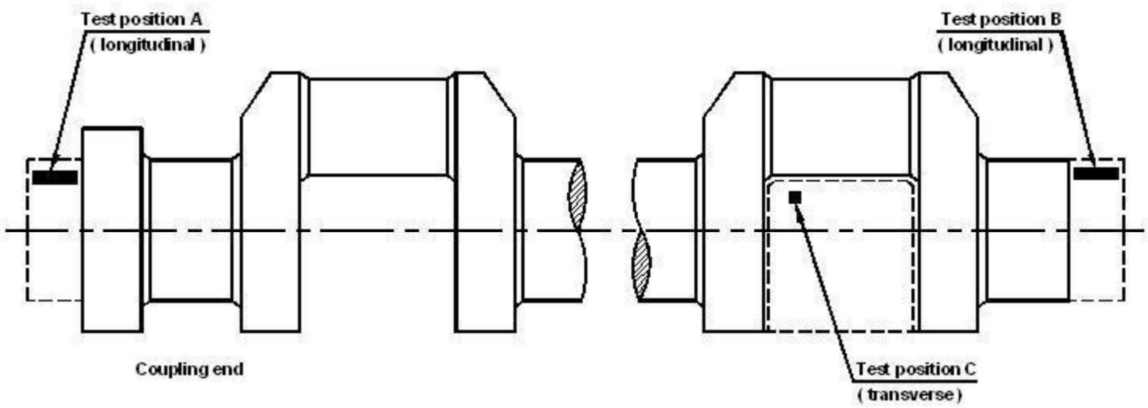



Fig.2.3.5h : Solid forged crankshaft

2.3.7 When a forging is subsequently divided into a number of components, all of which are heat treated together in the same furnace charge, for test purposes this may be regarded as one forging and the number of tests required is to be related to the total length and mass of the original multiple forging.

2.3.8 Except for components which are to be carburized or for hollow forgings where the ends are to be subsequently closed, test material is not to be cut from a forging until all heat treatment has been completed.

2.3.9 When forgings are to be carburized sufficient test material is to be provided for both preliminary tests in the as forged condition and for final tests after completion of carburizing.

For this purpose duplicate sets of test material are to be taken from positions as detailed in 2.3.5, except that irrespective of the dimensions or mass of the forging, tests are required from one position only and in the case of forgings with integral journals, are to be cut in a longitudinal direction.

This test material is to be machined to a diameter of D/4 or 60 [mm], whichever is less, where D is the finished diameter of the toothed portion.

For preliminary tests, one set of test material should be given a blank carburizing and it should undergo same heat treated cycle which the forged material will be subjected to.

For final acceptance tests, the second set of test material is to be blank carburized and heat treated along with the forgings which they represent.

At the discretion of the forge master or gear manufacturer test samples of larger cross section may be either carburized or blank carburized, but these are to be machined to the required diameter prior to the final quenching and tempering heat treatment.

Alternative procedures for testing of forgings which are to be carburized may be specially agreed with Designated Authority/Classification Society.

2.3.10 Normalized forgings with mass upto 1000 [kg] each and quenched and tempered forgings with mass upto 500 [kg] each may be batch tested. A batch is to consist of forgings of similar shape and dimensions, made from the same heat of steel, heat treated in the same furnace charge and with a total mass not exceeding 6 tonnes for normalized forgings and 3 tonnes for quenched and tempered forgings respectively.

2.3.11 A batch testing procedure may also be used for hot rolled bars. A batch is to consist of either:

i) material from the same rolled ingot or bloom provided that where this is cut into individual lengths, these are all heat treated in the same furnace charge, or

ii) bars of the same diameter and heat, heat treated in the same furnace charge and with a total mass not exceeding 2.5 tonnes.

2.3.12 The preparation of test specimens and the procedures used for mechanical testing are to comply with the relevant requirements of Ch.2 of this annex. Unless otherwise agreed all tests are to be carried out in the presence of the Surveyor.

**2.4 Mechanical properties**

2.4.1 Table 2.4.1 and Table 2.4.2 gives the minimum requirements for yield stress, elongation, reduction of area and impact test energy values corresponding to different strength levels but it is not tended that these should necessarily be regarded as specific grades. Where it is proposed to use a steel with a specified minimum tensile strength intermediate to those given, corresponding minimum values for the other properties may be obtained by interpolation.

2.4.2 Forgings may be supplied to any specified minimum tensile strength selected within the general limits detailed in Table 2.4.1 and Table 2.4.2 but subject to any additional requirements of the relevant construction rules.

2.4.3 The mechanical properties are to comply with the requirements of Table 2.4.1 and Table 2.4.2 appropriate to the specified minimum tensile strength or, where applicable the requirements of the approved specification.

2.4.4 At the discretion of Designated Authority/Classification Society hardness tests may be required in the following cases:

i) Gear forgings after completion of heat treatment and prior to machining the gear teeth:

The hardness is to be determined at four positions equally spaced around the circumference of the surface where teeth will subsequently be cut. Where the finished diameter of the toothed portion exceeds 2.5 [m], the above number of test positions is to be increased to eight. Where the width of a gear wheel rim forging exceeds 1.25 [m], the hardness is to be determined at eight positions at each end of the forging.

ii) Small crankshaft and gear forgings which have been batch tested:

In such cases at least one hardness test is to be carried out on each forging.

The results of hardness tests are to be reported and, for information purposes, typical Brinell hardness values are given in Table 2.4.2.

2.4.5 Hardness tests may also be required on forgings which have been induction hardened, nitrided or carburized. For gear forgings these tests are to be carried out on the teeth after, where applicable, they have been ground to the finished profile. The results of such tests including depth of hardening are to comply with the approved specifications. (See 1.5.6).

2.4.6 Where the result of a tensile test does not comply with the requirements, two additional tests may be taken. If satisfactory results are obtained from both of these additional tests the forging or batch of forgings is acceptable. If one or both retests fail the forging or batch of forgings is to be rejected.

2.4.7 Where the results from a set of three impact test specimens do not comply with the requirements an additional set of three impact test specimens may be taken provided that not more than two individual values are less than the required average value and of these not more than one is less than 70% of this average value. The results obtained are to be combined with the original results to form a new average which, for acceptance of the forgings or batch forgings, is to be not less than the required average value.

Additionally, for these combined results not more than two individual values are to be less than the required average value and of these not more than one is to be less than 70% of this average value.

2.4.8 The additional tests detailed in 2.4.6 and 2.4.7 are to be taken, preferably from material adjacent to the original tests, but alternatively from another test position or sample representative of the forging or hatch of forgings.

2.4.9 At the option of the manufacturer, when a forging or a batch of forgings has failed to meet the test requirements, it may be re- heat treated and re-submitted for acceptance tests.

**Table 2.4.1 : Mechanical properties for hull steel forgings**

| Steel type | Tensile strength 1) $R_m$ min. [N/mm$^2$] | Yield stress $R_e$ min. [N/mm$^2$] | Elongation as min. % | | Reduction of area Z min. % | |
|---|---|---|---|---|---|---|
| | | | Long. | Tang. | Long. | Tang. |
| C and | 400 | 200 | 26 | 19 | 50 | 35 |
| C-Mn | 440 | 220 | 24 | 18 | 50 | 35 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 480 | 240 | 22 | 16 | 45 | 30 |
| | 520 | 260 | 21 | 15 | 45 | 30 |
| | 560 | 280 | 20 | 14 | 40 | 27 |
| | 600 | 300 | 18 | 13 | 40 | 27 |
| Alloy | 550 | 350 | 20 | 14 | 50 | 35 |
| | 600 | 400 | 18 | 13 | 50 | 35 |
| | 650 | 450 | 17 | 12 | 50 | 35 |

1) The following ranges for tensile strength may be additionally specified:

specified minimum tensile strength : < 600 [N/mm$^2$] ≥ 600 [N/mm$^2$]

tensile strength range : 120 [N/mm$^2$] 150 [N/mm$^2$]

**Table 2.4.2 : Mechanical properties for machinery steel forgings [2)]**

| Steel type | Tensile strength[1)] Rm min. [N/mm$^2$] | Yield stress Re min. [N/mm$^2$] | Elongation As min % | | Reduction of area Z min. % | | Hardness [3)] (Brinell) |
|---|---|---|---|---|---|---|---|
| | | | Long. | Tang. | Long. | Tang. | |
| C and C-Mn | 400 | 200 | 26 | 19 | 50 | 35 | 110-150 |
| | 440 | 220 | 24 | 18 | 50 | 35 | 125-160 |
| | 480 | 240 | 22 | 16 | 45 | 30 | 135-175 |
| | 520 | 260 | 21 | 15 | 45 | 30 | 150-185 |
| | 560 | 280 | 20 | 14 | 40 | 27 | 160-200 |
| | 600 | 300 | 18 | 13 | 40 | 27 | 175-215 |
| | 640 | 320 | 17 | 12 | 40 | 27 | 185-230 |
| | 680 | 340 | 16 | 12 | 35 | 24 | 200-240 |
| | 720 | 360 | 15 | 11 | 35 | 24 | 210-250 |
| | 760 | 380 | 14 | 10 | 35 | 24 | 225-265 |
| Alloy | 600 | 360 | 18 | 14 | 50 | 35 | 175-215 |
| | 700 | 420 | 16 | 12 | 45 | 30 | 205-245 |
| | 800 | 480 | 14 | 10 | 40 | 27 | 235-275 |
| | 900 | 630 | 13 | 9 | 40 | 27 | 260-320 |
| | 1000 | 700 | 12 | 8 | 35 | 24 | 290-365 |
| | 1100 | 770 | 11 | 7 | 35 | 24 | 320-385 |

**Table 2.4.2 (Contd.)**

1) The following ranges for tensile strength may be additionally specified:

specified minimum tensile strength : < 600 [N/mm$^2$] ≥ 600 [N/mm$^2$]

tensile strength range : 120 [N/mm$^2$] 150 [N/mm$^2$]

2) For propeller shafts intended for ships with ice class notation except the lowest one, Charpy V-notch impact testing is to be carried out for all steel types at –10°C and the average energy value is to be minimum 27J (longitudinal test). One individual value may be less than the required average value provided that it is not less than 70% of this average value.

3) The hardness values are typical and are given for information purposes only.

## Section 3

## Ferritic Steel Forgings for Low Temperature Service

### 3.1 Scope

3.1.1 The requirements for carbon-manganese and nickel steels suitable for low temperature service are detailed in this section. They are applicable to all forgings with material thickness up to and including 50 [mm] used for the construction of cargo tanks, storage tanks and process pressure vessels for liquefied gases and where the design temperature is less than 0°C, to forgings for the piping systems.

3.1.2 The requirements are also applicable to forgings for other pressure vessels and pressure piping systems where the use of steels with guaranteed impact properties at low temperatures is required.

### 3.2 Chemical composition

3.2.1 The chemical composition of ladle samples is, in general, to comply with the requirements given in Table 3.2.1 of Ch.3.

### 3.3 Heat treatment

3.3.1 Forgings are to be normalized, normalized and tempered or quenched and tempered in accordance with the approved specification.

### 3.4 Mechanical tests

3.4.1 At least one tensile and three V-notch impact test specimens are to be taken from each forging or each batch of forgings. Where

the dimensions and shape allow, the test specimens are to be cut in a longitudinal direction.

3.4.2 The impact tests are to be carried out at a temperature appropriate to the type of steel and for the proposed application. Where forgings are intended for ships for liquefied gases the test temperature is to be in accordance with the requirements given in Table 5.4.1 of Ch.3, Sec.5.

3.4.3 The results of all tensile tests are to comply with the approved specification.

3.4.4 The average energy values for impact tests are also to comply with the approved specification and generally with the requirements of Ch.3, Sec.5. See also Ch.2.

3.4.5 For material thickness above 50 [mm], the material properties are to be agreed.

### 3.5 Pressure tests

3.5.1 When applicable, pressure tests are to be carried out in accordance with the requirements of the relevant construction Rules.

## Section 4

## Austenitic Stainless Steel Forgings

### 4.1 General

4.1.1 Forgings in austenitic stainless steels are acceptable for use in the construction of cargo tanks, storage tanks and piping systems for chemicals and liquefied gases. They may also be accepted for elevated temperature service in boilers.

4.1.2 Where it is proposed to use forgings in these types of steels, details of the chemical composition, heat treatment and mechanical properties are to be submitted for approval. These are to comply in general, with the requirements of Chapter 3, Section 9 for austenitic steel plates.

4.1.3 Unless otherwise specified, impact tests are not required for acceptance purposes. Where they are required tests are to be made on longitudinal specimens at minus 196°C and the minimum average energy requirements is to be 41J.

### 4.2 Mechanical properties for design purposes

4.2.1 Where austenitic stainless steel forgings are intended for service at elevated temperatures, the nominal values for the minimum one per cent proof stress at temperatures of 100°C and higher given in Table 4.2.1 may be used for design purposes. Verification of these values is not required except for material complying with a National or proprietary specification in which the elevated temperature properties proposed for design purposes are higher than those given in Table 4.2.1.

### 4.3 Non-destructive testing

4.3.1 Non-destructive testing is to be carried out in accordance with the requirements of Designated Authority/Classification Society and as agreed between the manufacturer, purchaser and Designated Authority/Classification Society.

### 4.4 Intergranular corrosion tests

4.4.1 Where corrosive conditions are anticipated in service, intergranular corrosion tests are required on forgings in Grades 304, 316 and 317. Such tests may not be required for Grades 304L, 316L, 321 and 347.

4.4.2 When an intergranular corrosion test is specified, it is to be carried out in accordance with the standard referred in Section 9.6.2 of Chapter 3.

**Table 4.2.1 : Mechanical properties for design purposes : austenitic stainless steels**

| Grade | Nominal 1% proof stress [N/mm$^2$] at a temperature | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100° C | 150° C | 200° C | 250° C | 300° C | 350° C | 400° C | 450° C | 500° C | 550° C | 600° C | 650° C | 700° C |
| 304L | 168 | 150 | 137 | 128 | 122 | 116 | 110 | 108 | 106 | 102 | 100 | 96 | 93 |
| 316L | 177 | 161 | 149 | 139 | 133 | 127 | 123 | 119 | 115 | 112 | 110 | 107 | 105 |
| 316LN | 238 | 208 | 192 | 180 | 172 | 166 | 161 | 157 | 152 | 149 | 144 | 142 | 138 |
| 321 | 192 | 180 | 172 | 164 | 158 | 152 | 148 | 144 | 140 | 138 | 135 | 130 | 124 |
| 347 | 204 | 192 | 182 | 172 | 166 | 162 | 159 | 157 | 155 | 153 | 151 | - | - |

## Chapter 6

## Steel Pipes and Tubes

**Contents**

**Section**



## Section 1

## General Requirements

### 1.1 Scope

1.1.1 The requirements of this Chapter are applicable to boiler tubes, superheater tubes and pipes intended for use in the construction of boilers, pressure vessels and ship and machinery pressure piping systems.

1.1.2 In addition to specifying mechanical properties for the purpose of acceptance testing, these requirements give details of appropriate mechanical properties at elevated temperatures to be used for design purposes.

1.1.3 Except for pipes for Class III pressure systems (as defined in Annex3, Ch.2) all pipes and tubes are to be manufactured and tested in accordance with the requirements of Ch.1 and 2 of this Part, the general requirements of this Section and the appropriate requirements given in Sec.1 to 5.

1.1.4 Steels, intended for the cargo and process piping systems of ships for liquefied gases where the design temperature is less than 0°C, are to comply with specific requirements of Sec.5.

1.1.5 Pipes and tubes, which comply with national or proprietary specifications may be accepted provided that these specifications give reasonable equivalence to the requirements of this Section or are otherwise specially approved for a specific application and provided that survey is carried out in accordance with Ch.1 of this Annex.

1.1.6 At the discretion of the Surveyor, a modified testing procedure may be adopted for small quantities of materials. In such cases, these may be accepted on the manufacturer's declared chemical composition and hardness tests or other evidence of satisfactory properties.

1.1.7 Pipes for Class III pressure systems are to be manufactured and tested in accordance with the requirements of an acceptable national specification. The manufacturer's test certificate will be acceptable and is to be provided for each consignment of material. Forge butt welded pipes are not acceptable for certain applications as detailed in Annex 3 Ch.2 and Annex 4, Ch.2.3.

**1.2 Manufacture**

1.2.1 Pipes for Class I and II pressure systems, boilers and superheater tubes are to be manufactured at works approved by Designated Authority/Classification Society. Also refer Chapter 1, Section 1, Cl. 1.3.2. The steel used is to be manufactured in accordance with Ch.3, Sec.1.

1.2.2 Unless a particular method is requested by the purchaser, pipes and tubes may be manufactured by any of the following methods:-

a) hot finished seamless;

b) cold finished seamless;

c) electric resistance or induction welded;

d) cold finished electric resistance or induction welded;

e) electric fusion welded.

1.2.3 Care is to be taken during manufacture that the pipe or tube surfaces coming in contact with any non-ferrous metals or their compounds are not contaminated to such an extent as could prove harmful during subsequent fabrication and operation.

**1.3 Quality**

1.3.1 All pipes and tubes are to have a workmanlike finish and are to be clean and free from such surface and internal defects as can be established by the specified tests.

1.3.2 All pipes and tubes are to be reasonably straight. The ends are to be cut nominally square with the axis of the pipes or tubes, and are to be free from excessive burrs.

1.3.3 The tolerances on the wall thickness and diameter of pipes and tubes are to be in accordance with an acceptable national / international standards.

**1.4 Chemical composition**

1.4.1 The requirements for the chemical composition of the ladle sample and the acceptable method of de-oxidation is to comply with the requirements detailed in the relevant Section of this Chapter.

**1.5 Heat treatment**

1.5.1 All pipes and tubes are to be supplied in the condition detailed in the relevant specific requirements.

**1.6 Test material**

1.6.1 Pipes and tubes are to be presented for test in batches. The size of a batch and the number of tests to be performed are dependent on the application.

1.6.2 Where heat treatment has been carried out, a batch is to consist of pipes or tubes of the same size, manufactured from the same type of steel and subjected to the same finishing treatment in a continuous furnace, or heat treated in the same furnace charge in a batch type furnace.

1.6.3 Where no heat treatment has been carried out, a batch is to consist of pipes or tubes of the same size manufactured by the same method from material of the same type of steel.

1.6.4 For pipes for class I pressure systems and boiler and superheater tubes, at least 2 per cent of the number of lengths in each batch is to be selected at random for the preparation of tests at ambient temperature.

1.6.5 For pipes for class II pressure systems, each batch is to contain not more than the number of lengths given in the following Table. Tests are to be carried out on at least one pipe selected at random from each batch or part thereof.

| Outside diameter [mm] | Number of pipes in a batch |
|---|---|
| ≤ 323.9 | 200 pipes as made |
| > 323.9 | 100 pipes as made |

**1.7 Test specimens and testing procedures**

1.7.1 The procedures for mechanical tests and the dimensions of the test specimens are to be in accordance with Ch.2.

**1.8 Visual and non-destructive testing**

1.8.1 All pipes for Class I and II pressure systems, boiler and superheater tubes are to be presented for visual examination and verification of dimensions. The manufacturer is to provide adequate lighting conditions to enable an internal and external examination of the pipes and tubes to be carried out.

1.8.2 For welded pipes and tubes the manufacturer is to employ suitable non-destructive methods for the quality control of the welds. It is preferred that this examination is carried out on a continuous basis.

**1.9 Hydraulic tests**

1.9.1 Each pipe and tube is to be subjected to a hydraulic test at the manufacturer's works.

1.9.2 The hydraulic test pressure is to be determined by the following formula, except that the maximum test pressure need not exceed 14 [N/mm$^2$].

$$P = \frac{2st}{D}$$

where,

P = test pressure [N/mm$^2$];

D = nominal outside diameter [mm];

t = nominal wall thickness [mm];

s = 80 per cent of the specified minimum yield

stress [N/mm$^2$], for ferritic steels and 70 per cent of the specified minimum 1.0 per cent proof stress [N/mm$^2$] for austenitic steels. These relate to the values specified for acceptance testing at ambient temperature.

1.9.3 The test pressure is to be maintained for sufficient time to permit proof and inspection. Unless otherwise agreed, the manufacturer's certificate of satisfactory hydraulic test will be accepted. Where it is proposed to adopt a test pressure other than determined as in 1.9.2, the proposal will be subject to special consideration.

**1.10 Rectification of defects**

1.10.1 Surface imperfections may be removed by grinding provided that the thickness of the pipe or tube after dressing is not less than the required minimum thickness. The dressed area is to be blended into the contour of the tube.

1.10.2 By agreement with the Surveyor, the repair of minor defects by welding can be accepted. Welding procedures, including preheating, post weld heat treatment and inspection, are to be to the complete satisfaction of the Surveyor. In all cases, the area is to be tested by magnetic particle examination, or in case of austenitic steels, by liquid penetrant examination on completion of welding, heat treatment and surface grinding.

**1.11 Identification**

1.11.1 Pipes and tubes are to be clearly marked by the manufacturer in accordance with the requirements of Ch.1. The following details are to be shown on all materials which have been accepted:-

a) Designated Authority/Classification Society mark

b) Manufacturer's name or trade mark;

c) Identification mark for the specification or grade of steel;

d) Identification number and/or initials which will enable the full history of the item to be traced;

e) The personal stamp of the Surveyor responsible for the final inspection.

1.11.2 It is recommended that hard stamping be restricted to the end face, but it may be accepted in other positions in accordance with national standards and practices.

**1.12 Certification**

1.12.1 The manufacturer is to provide the Surveyor with copies of test certificate or shipping statement for all material which has been accepted.

1.12.2 Each test certificate is to contain the following particulars:-

a) Purchaser's name and order number;

b) The yard number for which the material is intended, if known;

c) Address to which material is despatched;

d) Specification or the grade of material;

e) Description and dimensions;

f) Identification number and/or initials;

g) Cast number and chemical composition of ladle samples;

h) Mechanical test results, and results of the intercrystalline corrosion tests where applicable;

i) Condition of supply.

1.12.3 The chemical composition stated on the certificate is to include the content of all the elements detailed in the specific requirements. Where rimmed steel is supplied, this is to be stated on the certificate.

1.12.4 When steel is not produced at the pipe or tube mill, a certificate is to be supplied by the steelmaker stating the process of manufacture, the cast number and the ladle analysis.

1.12.5 The works at which the steel was produced must be approved by Designated Authority/Classification Society. Also refer Chapter 1, Section 1, Cl. 1.3.2.

## Section 2

## Seamless Pressure Pipes

**2.1 General**

2.1.1 Following requirements are applicable for seamless pressure pipes in carbon, carbon-manganese and low alloy steels.

2.1.2 Where pipes are used for the manufacture of pressure vessel shells and headers, the requirements of forgings in Ch.5 are applicable where the wall thickness exceeds 40 [mm].

**2.2 Manufacture and chemical composition**

2.2.1 Tubes are to be manufactured by a seamless process and may be hot or cold finished.

2.2.2 The method of de-oxidation and the chemical composition of ladle samples are to comply with the appropriate requirements given in Table 2.2.1.

**2.3 Heat treatment**

2.3.1 Pipes are to be supplied in the condition given in Table 2.3.1.

| Table 2.3.1 : Heat treatment | |
|---|---|
| **Type of steel** | **Condition of supply** |
| **Carbon and carbon-manganese** | |
| Hot finished | Not finished[1] |
| | Normalized[2] |
| Cold finished | Normalized[2] |
| Alloy steels | |
| 1 Cr $\frac{1}{2}$ Mo | Normalized and tempered |
| 2 $\frac{1}{4}$ Cr 1 Mo | |
| Grade 410 | Fully annealed |
| Grade 490 | Normalized and tempered 650-750°C |
| $\frac{1}{2}$ Cr $\frac{1}{2}$ Mo $\frac{1}{4}$ V | Normalized and tempered |

Notes:

1. Provided that the finishing temperature is sufficiently high to soften the material.
2. Normalized and tempered at the option of the manufacturer.

**Table 2.2.1 : Chemical composition of seamless pressure pipes**

| Type of steel | Grade | Method of deoxi-dation | Chemical composition of ladle samples % | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | C | Si | Mn | S max | P max | Residual elements | | | | | | |
| Carbon and carbon-manganese | 320 | Semi-killed or killed | ≤ 0.16 | - | 0.40-0.70 | 0.050 | 0.050 | Ni 0.30 max., Cr 0.25 max., Mo 0.10 max., Cu 0.30 max. Total 0.70 max. | | | | | | |
| | 360 | | ≤ 0.17 | ≤ 0.35 | 0.40-0.80 | 0.045 | 0.045 | | | | | | | |
| | 410 | Killed | ≤ 0.21 | ≤ 0.35 | 0.40-1.20 | 0.045 | 0.045 | | | | | | | |
| | 460 | Killed | ≤ 0.22 | ≤ 0.35 | 0.80-1.40 | 0.045 | 0.045 | | | | | | | |
| | 490 | Killed | ≤ 0.23 | ≤ 0.35 | 0.80-1.50 | 0.045 | 0.045 | | | | | | | |
| | | | | | | | | Ni | Cr | Mo | Cu | Sn | V | Al |
| 1 Cr $\frac{1}{2}$ Mo | 440 | Killed | 0.10-0.18 | 0.10-0.35 | 0.40-0.70 | 0.040 | 0.040 | 0.30 max. | 0.70-1.10 | 0.45-0.65 | 0.25 max. | 0.03 max. | - | ≤ 0.020 |
| 2 $\frac{1}{4}$ Cr 1 Mo | 410 490 | Killed | 0.08-0.15 | 0.10-0.50 | 0.40-0.70 | 0.040 | 0.040 | 0.30 max. | 2.0-2.5 | 0.90-1.20 | 0.25 max. | 0.03 max. | - | ≤ 0.020 |
| $\frac{1}{2}$ Cr $\frac{1}{2}$ Mo $\frac{1}{4}$ V | 460 | Killed | 0.10-0.18 | 0.10-0.35 | 0.40-0.70 | 0.040 | 0.040 | 0.30 max. | 0.30-0.60 | 0.50-0.70 | 0.25 max. | 0.03 max. | 0.22-0.32 | ≤ 0.020 |

**2.4 Mechanical tests**

2.4.1 All pipes are to be presented in batches as defined in Sec.1.

2.4.2 Each pressure pipe selected for test is to be subjected to tensile and flattening or bend tests.

2.4.3 The results of all mechanical tests are to comply with the appropriate requirements given in Table 2.4.1.

**2.5 Mechanical properties for design**

2.5.1 Values for nominal minimum lower yield or 0.2 per cent proof stress at 50°C and higher are given in Table 2.5.1 and are intended for design purposes only. Verification of these values is not required, except for materials complying with national or proprietary specifications where the elevated temperature properties used for design are higher than those given in Table 2.5.1.

2.5.2 In such cases, at least one tensile test at the proposed design or other agreed temperature is to be made on each cast. The test specimen is to be taken from material adjacent to that used for tests at ambient temperature and tested in accordance with the procedures given in Ch.2. If tubes or pipes of more than one thickness are supplied from one cast, the test is to be made on the thickest tube or pipe.

2.5.3 As an alternative to 2.5.2, a manufacturer may carry out an agreed comprehensive test program for a stated grade of steel to demonstrate that the specified minimum mechanical properties at elevated temperatures can be consistently obtained. This test program is to be carried out under the supervision of the Surveyors, and the results submitted for assessment and approval. When a manufac-turer is approved on this basis, tensile tests at elevated temperatures are not required for acceptance purposes, but at the discretion of the Surveyors, occasional check tests of this type may be requested.

2.5.4 Values for the estimated average stress to rupture in 100,000 hours are given in Table 2.5.2 and may be used for design purposes.

**Table 2.4.1 : Mechanical properties for acceptance purposes : Seamless pressure pipes (maximum wall thickness 40 mm)**

| Type of steel | Grade | Yield stress [N/mm$^2$] min. | Tensile strength [N/mm$^2$] | Elongation on $5.65\sqrt{S_o}$% min. | Flattening test constant C | Bend test diameter of former ( t = thickness) |
|---|---|---|---|---|---|---|
| Carbon and carbon-manganese | 320 | 195 | 320-440 | 25 | 0.10 | 4t |
| | 360 | 215 | 360-480 | 24 | 0.10 | 4t |
| | 410 | 235 | 410-530 | 22 | 0.08 | 4t |
| | 460 | 265 | 460-580 | 21 | 0.07 | 4t |
| | 490 | 285 | 490-610 | 21 | 0.07 | 4t |
| 1 Cr $\frac{1}{2}$ Mo | 440 | 275 | 440-590 | 22 | 0.07 | 4t |
| $2\frac{1}{4}$ Cr 1 Mo | 410 [1] | 135 | 410-560 | 20 | 0.07 | 4t |
| | 490 [2] | 275 | 490-640 | 16 | 0.07 | 4t |
| $\frac{1}{2}$ Cr $\frac{1}{2}$ Mo $\frac{1}{4}$ V | 460 | 275 | 460-610 | 15 | 0.07 | 4t |

Notes:

1 Annealed condition

2 Normalized and tempered condition

**Table 2.5.1 : Mechanical properties for design purposes : Seamless pressure pipes**

| Type of steel | Grade | Nominal minimum lower yield or 0.2% proof stress [N/mm$^2$] Temperature °C | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 50 | 100 | 150 | 200 | 250 | 300 | 350 | 400 | 450 | 500 | 550 | 600 |
| Carbon and carbon-manganese | 320 | 172 | 168 | 158 | 147 | 125 | 100 | 91 | 88 | 87 | - | - | - |
| | 360 | 192 | 187 | 176 | 165 | 145 | 122 | 111 | 109 | 107 | - | - | - |
| | 410 | 217 | 210 | 199 | 188 | 170 | 149 | 137 | 134 | 132 | - | - | - |
| | 460 | 241 | 234 | 223 | 212 | 195 | 177 | 162 | 159 | 156 | - | - | - |
| | 490 | 256 | 249 | 237 | 226 | 210 | 193 | 177 | 174 | 171 | - | - | - |
| 1 Cr $\frac{1}{2}$ Mo | 440 | 254 | 240 | 230 | 220 | 210 | 183 | 169 | 164 | 161 | 156 | 151 | - |
| $2\frac{1}{4}$ Cr 1 Mo | 410 [1] | 121 | 108 | 99 | 92 | 85 | 80 | 76 | 72 | 69 | 66 | 64 | 62 |
| | 490 [2] | 268 | 261 | 253 | 245 | 236 | 230 | 224 | 218 | 205 | 189 | 167 | 145 |
| $\frac{1}{2}$ Cr $\frac{1}{2}$ Mo $\frac{1}{4}$ V | 460 | 266 | 259 | 248 | 235 | 218 | 192 | 184 | 177 | 168 | 155 | 148 | - |

Notes:

1 Annealed condition

2 Normalized and tempered condition

**Table 2.5.2 : Mechanical properties for design purposes : Seamless pressure pipes - estimated values for stress to rupture in 100 000 hours (units [N/mm$^2$])**

| Temperature °C | Carbon and carbon-manganese | | 1 Cr $\frac{1}{2}$ Mo | $2\frac{1}{4}$ Cr 1 Mo | | $\frac{1}{2}$ Cr $\frac{1}{2}$ Mo $\frac{1}{4}$ V |
|---|---|---|---|---|---|---|
| | **Grade 320, 360, 410** | **Grade 460, 490** | **Grade 440** | **Grade 410 Annealed** | **Grade 490 Normalized and tempered (see Note)** | **Grade 460** |
| 380 | 171 | 227 | - | - | - | - |
| 390 | 155 | 203 | - | - | - | - |
| 400 | 141 | 179 | - | - | - | - |
| 410 | 127 | 157 | - | - | - | - |
| 420 | 114 | 136 | - | - | - | - |
| 430 | 102 | 117 | - | - | - | - |
| 440 | 90 | 100 | - | - | - | - |
| 450 | 78 | 85 | - | 196 | 221 | - |
| 460 | 67 | 73 | - | 182 | 204 | - |
| 470 | 57 | 63 | - | 168 | 186 | - |
| 480 | 47 | 55 | 210 | 154 | 170 | 218 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 490 | 36 | 47 | 177 | 141 | 153 | 191 |
| 500 | - | 41 | 146 | 127 | 137 | 170 |
| 510 | - | - | 121 | 115 | 122 | 150 |
| 520 | - | - | 99 | 102 | 107 | 131 |
| 530 | - | - | 81 | 90 | 93 | 116 |
| 540 | - | - | 67 | 78 | 79 | 100 |
| 550 | - | - | 54 | 69 | 69 | 85 |
| 560 | - | - | 43 | 59 | 59 | 72 |
| 570 | - | - | 35 | 51 | 51 | 59 |
| 580 | - | - | - | 44 | 44 | 46 |
| Note : When tempering temperature exceeds 750°C, the values for Grade 410 are to be used. | | | | | | |

**Section 3**

**Welded Pressure Pipes**

**3.1 General**

3.1.1 Following requirements are applicable to welded pressure pipes in carbon, carbon-manganese and low alloy steels.

3.1.2 Where it is proposed to use submerged arc longitudinally welded pipes, details of the specification are to be submitted.

**3.2 Manufacture and chemical composition**

3.2.1 Pipes are to be manufactured by the electric or induction welding process and, if required, may be subsequently hot reduced or cold finished.

3.2.2 The method of de-oxidation and the chemical composition of ladle samples are to comply with the appropriate requirements given in Table 3.2.1.

3.2.3 Where rimmed steel is used, the strips are to be rolled in single widths and not slit longitudinally, except to trim the edges.

**Table 3.2.1 : Chemical composition of welded pressure pipes**

| Type of steel | Grade | Method of deoxidation | Chemical composition of ladle samples % | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | C | Si | Mn | S max. | P max. | Residual elements | | | | | |
| Carbon and carbon-manganese | 320 | Any method (see Note) | ≤ 0.16 | - | 0.30-0.70 | 0.050 | 0.050 | Ni 0.30 max., Cr 0.25 max., Mo 0.10 max., Cu 0.30 max. Total 0.70 max. | | | | | |
| | 360 | | ≤ 0.17 | ≤ 0.35 | 0.40-1.00 | 0.045 | 0.045 | | | | | | |
| | 410 | Killed | ≤ 0.21 | ≤ 0.35 | 0.40-1.20 | 0.045 | 0.045 | | | | | | |
| | 460 | Killed | ≤ 0.22 | ≤ 0.35 | 0.80-1.40 | 0.045 | 0.045 | | | | | | |
| | | | | | | | | Ni | Cr | Mo | Cu | Sn | Al |
| 1 Cr $\frac{1}{2}$ Mo | 440 | Killed | 0.10-0.18 | 0.10-0.35 | 0.40-0.70 | 0.040 | 0.040 | 0.30 max. | 0.70-1.10 | 0.45-0.65 | 0.25 max. | 0.03 max. | ≤ 0.020 |
| Note : For rimmed steels the carbon content may be increased to 0.19% max. | | | | | | | | | | | | | |

### 3.3 Heat treatment

3.3.1 Pipes are to be supplied in the heat treated condition given in Table 3.3.1.

**Table 3.3.1 : Heat treatment : Welded pressure pipes**

| Type of steel | Condition of supply |
|---|---|
| Carbon and carbon-manganese | Normalized (Normalized and tempered at the option of the manufacturer) |
| 1 Cr $\frac{1}{2}$ Mo | Normalized and tempered |

### 3.4 Mechanical tests

3.4.1 All pipes are to be presented in batches as defined in Sec.1.

3.4.2 Each pressure pipe selected for test is to be subjected to tensile and flattening or bend tests.

3.4.3 The results of all mechanical tests are to comply with the appropriate requirements given in Table 3.4.1.

### 3.5 Mechanical properties for design

3.5.1 The mechanical properties at elevated temperature for carbon and carbon-manganese steels in Grades 320 [N/mm$^2$] to 460 [N/mm$^2$] and 1 Cr $\frac{1}{2}$ Mo steel can be taken from the appropriate Tables in Sec.2.

3.5.2 Where rimmed steel is used, the design temperature is limited to 400°C.

**Table 3.4.1 : Mechanical properties for acceptance purposes : Welded pressure pipes**

| Type of steel | Grade | Yield stress [N/mm$^2$] | Tensile strength [N/mm$^2$] | Elongation on $5.65\sqrt{S_o}$% minimum | Flattening test constant C |
|---|---|---|---|---|---|
| Carbon and carbon-manganese | 320 | 195 | 320 - 440 | 25 | 0.10 |
| | 360 | 215 | 360 - 480 | 24 | 0.10 |
| | 410 | 235 | 410 - 530 | 22 | 0.08 |
| | 460 | 265 | 460 - 580 | 21 | 0.07 |
| 1 Cr $\frac{1}{2}$ Mo | 440 | 275 | 440 - 590 | 22 | 0.07 |

## Section 4

## Boiler and Superheater Tubes

### 4.1 General

4.1.1 The following requirements are applicable for boiler and superheater tubes in carbon, carbon-manganese and low alloy steels.

4.1.2 Austenitic stainless steels may also be used for this type of service. Where such applications are proposed, details of the chemical composition, heat treatment and mechanical properties are to be submitted for consideration and approval.

### 4.2 Manufacture and chemical composition

4.2.1 Tubes are to be seamless or welded and are to be manufactured in accordance with the requirements of Sec.2 and 3 respectively.

4.2.2 The method of de-oxidation and the chemical composition of ladle samples are to comply with the requirements given in Table 2.2.1 or Table 3.2.1, as appropriate.

### 4.3 Heat treatment

4.3.1 All tubes are to be supplied in accordance with the requirements given in Table 2.3.1 or Table 3.3.1 as appropriate, except that 1 Cr $\frac{1}{2}$ Mo steel may be supplied in the normalized only condition when the carbon content does not exceed 0.15 per cent.

### 4.4 Mechanical tests

4.4.1 Tubes are to be presented for test in batches as defined in Sec.1.

4.4.2 Each boiler and superheater tube selected for test is to be subjected to at least the following:

a) Tensile test;

b) Flattening or bending tests at the manufacturer's option;

c) Expanding or flanging tests at the manufacturer's option.

4.4.3 The results of all mechanical tests are to comply with the appropriate requirements given in Table 4.4.1.

**4.5 Mechanical properties for design**

4.5.1 The mechanical properties at elevated temperature for carbon and carbon-manganese steels in Grades 320 [N/mm$^2$] to 460 [N/mm$^2$], 1 Cr $\frac{1}{2}$ Mo and 2 $\frac{1}{4}$ Cr 1 Mo steels can be taken from the appropriate Tables in Sec.2.

4.5.2 Where rimmed steel is used, the design temperature is limited to 400°C.

**Table 4.4.1 : Mechanical properties for acceptance purposes : Boilers and superheater tubes**

| Type of steel | Grade | Yield stress [N/mm$^2$] | Tensile strength [N/mm$^2$] | Elongation on $5.65\sqrt{S_o}$% minimum | Flatten-ing test con-stant C | Bend test diame-ter of former (t=thickness) | Drift expanding and flanging test minimum % increase in outside diameter | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Ratio : Inside diameter / Outside diameter | | |
| | | | | | | | ≤ 0.6 | > 0.6 ≤ 0.8 | > 0.8 |
| Carbon and carbon-man-ganese | 320 | 195 | 320-440 | 25 | 0.10 | 4t | 12 | 15 | 19 |
| | 360 | 215 | 360-480 | 24 | 0.10 | 4t | 12 | 15 | 19 |
| | 410 | 235 | 410-530 | 22 | 0.08 | 4t | 10 | 12 | 17 |
| | 460 | 265 | 460-580 | 21 | 0.07 | 4t | 8 | 10 | 15 |
| 1 Cr $\frac{1}{2}$ Mo | 440 | 275 | 440-590 | 22 | 0.07 | 4t | 8 | 10 | 15 |
| 2 $\frac{1}{4}$ Cr 1 Mo | 410 [1] | 135 | 410-560 | 20 | 0.07 | 4t | 8 | 10 | 15 |
| | 490 [2] | 275 | 490-640 | 16 | 0.07 | 4t | 8 | 10 | 15 |

Notes:

1. Annealed condition
2. Normalized and tempered condition

## Section 5

## Tubes and Pipes for Low Temperature Services

**5.1 Scope**

5.1.1 This Section gives the requirements for seamless and welded carbon, carbon-manganese and nickel alloy steel pipes not exceeding 25 [mm] in thickness intended for use in liquefied gas piping systems where the design temperature is lower than 0°C and also for other pressure piping systems where guaranteed impact properties at low temperature is required.

**5.2 Manufacture**

5.2.1 The pipes are to be manufactured seamless or by a welding process, and may be hot or cold finished.

**5.3 Chemical composition**

5.3.1 The chemical composition of ladle samples is in general to comply with the requirements given in Table 5.3.1. Steels for the production of tubes and pipes are to be killed.

**Table 5.3.1 : Chemical composition**

| Type of steel | Grade | Method of deoxi-dation | Chemical composition of ladle sample % | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | C max. | Si | Mn | P max. | S max. | Ni | Al $_{met}$ | Residual Elements |
| Carbon | 360 | Fully killed | 0.17 | 0.10-0.35 | 0.40-1.00 | 0.045 | 0.045 | - | ≥ 0.015 see note | Cr 0.25 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Carbon-manganese | 410 & 460 | | 0.2 | 0.10-0.35 | 0.60-1.40 | 0.045 | 0.045 | - | ≥ 0.015 see note | Cu 0.30 Mo 0.10 Ni 0.30 Total 0.70 |
| 3.5 Ni | 440 | | 0.15 | 0.15-0.35 | 0.30-0.90 | 0.040 | 0.040 | 3.25-3.75 | - | Cr 0.25 Cu 0.30 Mo 0.10 Total 0.60 |
| 9 Ni | 690 | | 0.3 | 0.15-0.30 | 0.30-0.90 | 0.040 | 0.040 | 8.50-9.50 | - | |
| **Note** : Where a minimum $Al_{met}$ of 0.015% is specified, the determination of the total aluminium is acceptable provided that the result is not less than 0.018%. | | | | | | | | | | |

**5.4 Heat treatment**

5.4.1 Pipes are to be supplied in the condition given in Table 5.4.1.

| Table 5.4.1 : Heat treatment | |
|---|---|
| **Type of Steel** | **Condition of Supply** |
| Carbon and Carbon-manganese | Hot finished<br>Normalized<br>Normalized and tempered |
| 3.5 Ni | Normalized<br>Normalized and tempered |
| 9 Ni | Double normalized and tempered<br>Quenched and tempered |

**5.5 Mechanical tests**

5.5.1 All pipes are to be presented for test in batches as defined in Sec.1 pressure piping systems.

5.5.2 At least two percent of the number of lengths in each batch is to be selected at random for the preparation of the tests.

5.5.3 Each pipe or tube selected for test is to be subjected to following tests:

- Seamless pipes and tubes:
  - one tensile test
  - one set of impact tests
  - one flattening test or bend test or ring tensile test
  - one drift or one ring expanding test where appropriate.
- Welded tubes and pipes:
  - one tensile test on the base material
  - one tensile test on the weld for pipes with D ≥ 508 [mm]
  - one set of impact tests
  - two flattening tests or bend tests or one ring tensile test (ERW and IW)
  - one drift or one ring expanding test (ERW and IW) -two bend tests (SAW).

5.5.4 Ring tensile test may be carried out in conformity with ISO 8495 or other equivalent standard.

5.5.5 The impact tests are to consist of a set of three Charpy V-notch test specimens cut in the longitudinal direction with the notch perpendicular to the original surface of the pipe. The dimension of the test specimens are to be in accordance with the requirements of Ch.2. Impact testing is not required for wall thickness below 6 [mm].

5.5.6 The impact values are to be determined at the lowest test temperature specified for the steel grade and the wall thickness in question.

5.5.7 The results of all mechanical tests are to comply with the appropriate values given in Table 5.5.1.

5.5.8 The energy value from a set of three Charpy V-notch impact test specimens is not to be lower than the required average value given in Table 5.5.1. One individual value may be less than the required average value provided that it is not less than 70 per cent of this average value.

**Table 5.5.1 : Mechanical properties for acceptance purposes**

| **Type of steel** | **Grade** | **Yield stress [N/mm$^2$]** | **Tensile strength [N/mm$^2$]** | **Elonga-tion on 5.65 $\sqrt{S_o}$% min.** | **Flattening test constant C** | **Bend test diameter of former (t=thick-ness)** | **Charpy V-notch impact tests** | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | **Test tempera-ture °C** | **Average energy J minimum** |
| Carbon | 360 | 210 | 360-480 | 24 | 0.10 | 4t | -40 | 27 |
| Carbon- | 410 | 235 | 410-530 | 22 | 0.08 | 4t | -50 | 27 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| manga-nese | 460 | 260 | 460-580 | 21 | 0.07 | | -50 | 27 |
| 3.5 Ni | 440 | 245 | 440-590 | 16 | 0.08 | 4t | -100 | 27 |
| 9 Ni | 690 | 510 | 690-840 | 15 | 0.08 | 4t | -196 | 39 |

## Section 6

## Austenitic Stainless Steel Pressure Pipes

### 6.1 Scope

6.1.1 This section gives the requirements for austenitic stainless steel pipes suitable for use in the construction of the piping systems for chemicals and for liquefied gases where the design temperature is not less than –165°C.

6.1.2 Austenitic stainless steels are also suitable for service at elevated temperatures. Where such applications are proposed, details of the chemical composition, heat treatment and mechanical properties are to be submitted for consideration and approval. See also Annex 3, Ch.2, 1.9.5.

6.1.3 Where it is intended to supply seamless pipes in the direct quenched condition, a programme of tests for approval is to be carried out under the supervision of the Surveyors, and the results are to be to the satisfaction of Designated Authority/Classification Society.

### 6.2 Manufacture and chemical composition

6.2.1 Pipes are to be manufactured by a seamless or a continuous automatic electric fusion welding process.

6.2.2 Welding is to be in a longitudinal direction, with or without the addition of filler metal.

6.2.3 The chemical composition of the ladle samples is to comply with the appropriate requirements of Table 6.2.1.

**Table 6.2.1 : Chemical composition**

| Type of steel | Grade | Chemical composition of ladle sample % | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | C max. | Si | Mn | P max. | S max. | Cr | Mo | Ni | Others |
| 304L | 490 | 0.03 | <1.00 | <2.00 | 0.045 | 0.030 | 17.0-19.0 | - | 9.0-13.0 | - |
| 316L | 490 | 0.03 | <1.00 | <2.00 | 0.045 | 0.030 | 16.0-18.5 | 2.0-3.0 | 11.0-14.5 | - |
| 321 | 510 | 0.08 | <1.00 | <2.00 | 0.045 | 0.030 | 17.0-19.0 | - | 9.0-13.0 | Ti ≥ 5 xC ≤ 0.80 |
| 347 | 510 | 0.08 | <1.00 | <2.00 | 0.045 | 0.030 | 17.0-19.0 | - | 9.0-13.0 | Nb≥10 x C≤1.00 |

### 6.3 Heat treatment

6.3.1 Pipes are generally to be supplied by the manufacturer in the solution treated condition over their full length.

6.3.2 Alternatively, seamless pipes may be direct quenched immediately after hot forming, while the temperature of the pipes is not less than the specified minimum solution treatment temperature.

### 6.4 Mechanical tests

6.4.1 All pipes are to be presented in batches as defined in Section 1 for Class I and II piping systems.

6.4.2 Each pipe selected for test is to be subjected to tensile and flattening or bend tests.

6.4.3 The results of all mechanical tests are to comply with the appropriate requirements given in Table 6.4.1.

Where the design temperature is less than –105°C, impact tests are to be carried out on a set of three Charpy V-notch specimens. The tests are to be made on longitudinal specimens at –196°C and the average energy is to be not less than 41 Joules.

**Table 6.4.1 : Mechanical properties for acceptance purposes**

| Type of steel | Grade | 0.2% proof stress [N/mm$^2$] (see Note) | 1.0% proof stress [N/mm$^2$] | Tensile strength [N/mm$^2$] | Elongation on 5.65 $\sqrt{S_o}$ % minimum | Flattening test constant | Bend test diameter of former (t=thickness) |
|---|---|---|---|---|---|---|---|
| 304L | 490 | 175 | 205 | 490-690 | 30 | 0.09 | 3t |
| 316L | 490 | 185 | 215 | 490-690 | 30 | 0.09 | 3t |
| 321 | 510 | 195 | 235 | 510-710 | 30 | 0.09 | 3t |
| 347 | 510 | 205 | 245 | 510-710 | 30 | 0.09 | 3t |

Note : The 0.2% proof stress values given for information purposes and unless otherwise agreed are not required to be verified by test.

**6.5 Intergranular corrosion tests**

6.5.1 For materials used for piping systems for chemicals, intercrystalline corrosion tests are to be carried out on one per cent of the number of pipes in each batch, with a minimum of one pipe.

6.5.2 For pipes with an outside diameter not exceeding 40 [mm], the test specimens are to consist of a full cross section. For larger pipes, the test specimens are to be cut as circumferential strips of full wall thickness and having a width of not less than 12.5 [mm]. In both cases, the total surface areas is to be between 15 and 35 [cm$^2$].

6.5.3 When required, one test of this type is to be carried out for each tensile test. The testing is to be carried out in accordance with ASTM A262, practice E, copper-copper sulphate-sulphuric acid or another recognized standard. The bent specimen is to be free from cracks indicating the presence of intergranular attack. The material for the test is to be taken adjacent to that for the tensile test.

6.5.4 After immersion, the full cross-section test specimens are to be subjected to a flattening test in accordance with the requirements of Chapter 2. The strip test specimens are to be subjected to a bend test through 90° over a mandrel of diameter equal to twice the thickness of the test specimen.

**6.6 Fabricated pipework**

6.6.1 Fabricated pipework is to be produced from material manufactured in accordance with 6.2, 6.3, 6.4 and 6.5.

6.6.2 Welding is to be carried out in accordance with an approved and qualified procedure by suitably qualified welders.

6.6.3 Fabricated pipework may be supplied in the as-welded condition without subsequent solution treatment provided that welding procedure tests have demonstrated satisfactory material properties including resistance to intercrystalline corrosion.

6.6.4 In addition, butt welds are to be subjected to 5 per cent radiographic examination for Class I and 2 per cent for Class II pipes.

6.6.5 Fabricated pipework in the as-welded condition and intended for systems located on deck is to be protected by a suitable corrosion control coating.

## Chapter 7

## Iron Castings

**Contents**



### Section 1

### General Requirements

**1.1 Scope**

1.1.1 This Chapter gives the requirements for both grey and spheroidal or nodular graphite iron castings intended for ship and machinery construction.

1.1.2 All important iron castings, as defined in the relevant parts of the Rules dealing with design and construction, are to be manufactured and tested in accordance with the requirements of Ch.1 and 2 and the requirements given in the following paragraphs.

1.1.3 As an alternative to 1.1.2, castings which comply with National or Proprietary specifications may be accepted, provided that such specifications give reasonable equivalence to these requirements or otherwise are specially approved or required by Designated Authority/Classification Society.

1.1.4 Where small castings are produced in large quantities, the manufacturer may adopt alternative procedure for testing and inspection, subject to the approval of Designated Authority/Classification Society.

1.1.5 These requirements are applicable only to castings where the design and acceptance tests are related to mechanical properties at ambient temperature. For other applications additional requirements may be necessary, especially when the castings are intended for service at low or elevated temperatures.

**1.2 Manufacture**

1.2.1 All castings, as designated in1.1.2, are to be manufactured at foundries approved by Designated Authority/Classification Society.

1.2.2 Suitable mechanical methods are to be employed for the removal of surplus material from the castings. Thermal cutting processes are not acceptable, except as a preliminary operation to the mechanical methods.

1.2.3 Where castings of the same type are regularly produced in quantity, the manufacturer is to make any tests necessary to prove the quality of the prototype castings and is also to make periodical examinations to verify the continued efficiency of the manufacturing technique. The Surveyor is to be given the opportunity to witness these tests.

**1.3 Quality of castings**

1.3.1 Castings are to be free from surface or internal defects which could be prejudicial to their proper application in service. The surface finish is to be in accordance with good practice and any specific requirements of the approved plan.

**1.4 Chemical composition**

1.4.1 The chemical composition of the iron used is left to the discretion of the manufacturer, who is to ensure that it is suitable to obtain the mechanical properties specified for the castings.

**1.5 Heat treatment**

1.5.1 Except as required by 1.5.2, castings may be supplied in either the as cast or heat treated condition.

1.5.2 For some applications, such as high temperature service or where dimensional stability is important, castings may be required to be given a suitable tempering or stress relieving heat treatment. This is to be carried out after any refining heat treatment and before machining. The special qualities with 350 [N/mm$^2$] and 400 [N/mm$^2$] nominal tensile strength and impact test are to undergo ferritizing heat treatment.

1.5.3 Where it is proposed to locally harden the surface of castings, full details of the proposed procedure and specifications are to be submitted for approval by Designated Authority/Classification Society.

**1.6 Mechanical tests**

1.6.1 Separately cast test samples are to be used unless otherwise agreed between the manufacturer and the purchaser. The test samples are generally to be one of the standard types detailed in Fig.1.6.1, Fig.1.6.2 and Fig.1.6.3 with a thickness of 25 [mm]. Test samples of dimensions, other than as detailed in Fig.1.6.1 to Fig.1.6.3 may, however, be specially required for some components. For grey cast iron the test samples are to be in the form of cylindrical bars of 30 [mm] diameter and of suitable length. When two or more test samples are cast simultaneously in a single mould, the bars are to be at least 50 [mm] apart as indicated in Fig.1.6.4.

1.6.2 Integrally cast samples may be used when a casting is more than 20 [mm] thick and its mass exceeds 200 [kgs] subject to agreement between the manufacturer and the purchaser. The type and location of the test sample are to be selected to provide approximately the same cooling conditions as for the casting it represents.

1.6.3 At least one test sample is to be provided for each casting or batch of castings. A batch consists of castings poured from a single ladle of metal provided they are all of similar type and dimensions. A batch should not normally exceed two tonnes of fettled castings and a single casting will constitute a batch if its mass is two tonnes or more.

1.6.4 For continuous melting of same grade of cast iron in large tonnages the mass of the batch may be increased to the output of two hours of pouring. If production is carefully monitored by systematic checking of the melting process, such as chill testing, chemical analysis or thermal analysis, test samples may be taken at longer intervals.

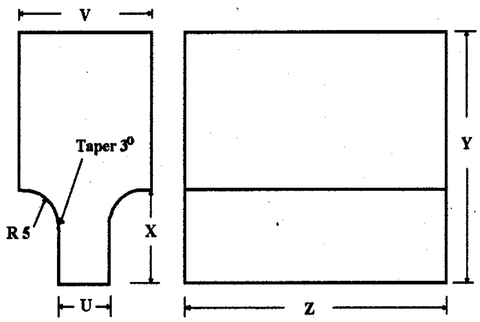
1.6.5 For large castings where more than one ladle of treated metal is used, additional test samples are to be provided so as to be representative of each ladle used.

1.6.6 All test samples are to be suitably marked to identify them with the castings which they represent.

1.6.7 Where castings are supplied in the heat treated condition, the test samples are to be heat treated together with the castings which they represent.

1.6.8 The test samples are to be cast in moulds made from the same type of material as used for the castings and are not to be stripped from the moulds until the metal temperature is below 500°C.

1.6.9 One tensile test specimen is to prepared from each test sample. The dimensions of the test specimens and the testing procedures used are to be in accordance with Ch.2.




| Standardsample | | Alternative samples, when required | | |
|---|---|---|---|---|
| U | 25 | 12 | 50 | 75 |
| V | 55 | 40 | 90 | 125 |
| X | 40 | 30 | 60 | 65 |
| Y | 100 | 80 | 150 | 185 |
| Z | To suit testing machine (approx. 150 [mm]) | | | |

**Fig.1.6.1 : Standard test specimen**

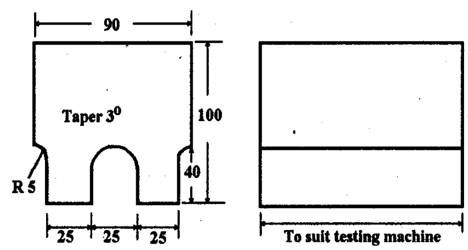
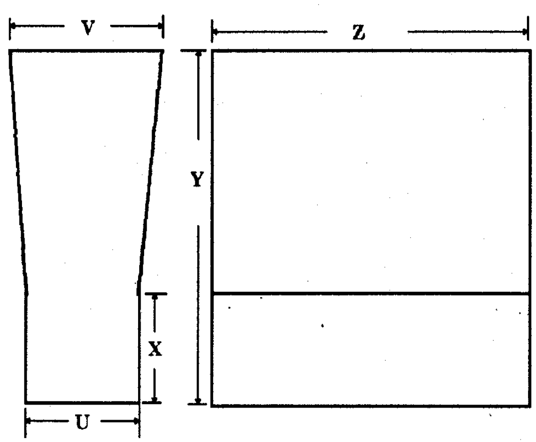



**Fig.1.6.2 : Standard test specimen**




| Standardsample | | Alternative samples, when required | | |
|---|---|---|---|---|
| U | 25 | 12 | 50 | 75 |
| V | 55 | 40 | 90 | 125 |
| X | 40 | 25 | 50 | 65 |
| Y | 140 | 135 | 150 | 175 |
| Z | To suit testing machine (approx. 150 [mm]) | | | |

**Fig.1.6.3 : Standard test specimen**

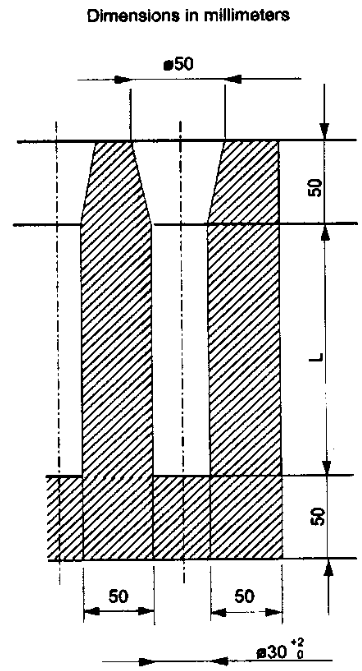



**Fig.1.6.4 : Test sample for grey cast iron**

### 1.7 Mechanical properties

1.7.1 For grey iron castings, only the tensile strength is to be determined and the results obtained are to comply with the minimum value specified for the castings being supplied. The specified minimum tensile strength is to be not less than 200 [N/mm$^2$] and not more than 350 [N/mm$^2$]. The fractured surfaces of all tensile test specimens are to be granular and grey in appearance.

1.7.2 For spheroidal or nodular graphite iron castings the tensile strength and elongation are to be determined. The results of all tests are to comply with the requirements of Table 1.7.1, but subject to any additional requirements of the relevant construction rules. Typical ranges of hardness values are also given in Table 1.7.1 and are intended for information purposes.

1.7.3 Retest requirements for tensile tests are to be in accordance with 1.10 of Chapter 1.

### 1.8 Visual and non-destructive examination

1.8.1 All castings are to be cleaned and adequately prepared for examination. The surfaces are not to be hammered, peened or treated in any way which may obscure defects.

**Table 1.7.1 : Mechanical properties for acceptance purposes (spheroidal or nodular graphite iron)**

| Specified Minimum Tensile Strength [N/mm²] | | 0.2% proof stress (see Note) [N/mm²] | Elongation on $5.65\sqrt{S_o}$ % min. | Typical Hardness Brinell (see para 1.7.2) | Impact Energy | | Typical structure of matrix (see para 1.9.2) |
|---|---|---|---|---|---|---|---|
| | | | | | Test Temp. °C | J Min.[2] | |
| Ordinary qualities | 370 | 230 | 17 | 120 - 180 | - | - | Ferrite |
| | 400 | 250 | 12 | 140 - 200 | - | - | Ferrite |
| | 500 | 320 | 7 | 170 - 240 | - | - | Ferrite/Pearlite |
| | 600 | 370 | 3 | 190 - 270 | - | - | Ferrite/Pearlite |
| | 700 | 420 | 2 | 230 - 300 | - | - | Pearlite |
| | 800 | 480 | 2 | 250 - 350 | - | - | Pearlite or Tempered Structure |
| Special qualities | 350 | 220 | 22[3] | 110 - 170 | 20 | 17(14) | Ferrite |
| | 400 | 250 | 18[3] | 140 - 200 | 20 | 14(11) | Ferrite |

Notes:

1. For intermediate values of specified minimum tensile strength, the minimum values for 0.2% proof and elongation may be obtained by interpolation.
2. The average value measured on 3 Charpy V-notch specimens. One result may be below the average value but not less than the minimum shown in brackets.
3. In the case of integrally cast samples, the elongation may be 2 percentage points less.

1.8.2 Before acceptance, all castings are to be visually examined including, where applicable, the examination of internal surfaces. Unless otherwise agreed the verification of dimensions is the responsibility of the manufacturer.

1.8.3 Supplementary examination of castings by suitable non-destructive testing procedures is generally not required except in circumstances where there is reason to suspect the soundness of the casting.

1.8.4 When required by the relevant construction Rules, castings are to be pressure tested before final acceptance.

1.8.5 Cast crankshafts are to be subjected to a magnetic particle inspection. Crack like indications are not permitted.

**1.9 Metallographic examination**

1.9.1 For spheroidal or nodular graphite iron castings, a representative sample from each ladle of treated metal is to be prepared for metallographic examination. These samples may conveniently be taken from the tensile test specimens but alternative arrangement for the provision of the samples may be adopted provided that they are taken from the ladle towards the end of the casting period.

1.9.2 Examination of the samples is to show that at least 90 per cent of the graphite is in a dispersed spheroidal or nodular form. Details of the typical matrix structure are given in Table 1.7.1 and are intended for information purposes only.

**1.10 Rectification of defective castings**

1.10.1 At the discretion of the Surveyor, small surface blemishes may be removed by local grinding.

1.10.2 Subject to the prior approval of the Surveyor, castings containing local porosity may be rectified by impregnation with a suitable plastic filler, provided that the extent of the porosity is such that it does not adversely affect the strength of the castings.

1.10.3 Repairs by welding are generally not permitted, but may be considered in special circumstances. In such cases, full details of the proposed repair procedure are to be submitted for approval prior to commencement of the proposed rectification.

### 1.11 Identification of castings

1.11.1 The manufacturer is to adopt a system of identification which will enable all finished castings to be traced to the original ladle of treated metal and the Surveyor is to be given full facilities for so tracing the castings when required.

1.11.2 Before acceptance, all castings which have been tested and inspected with satisfactory results are to be clearly marked by the manufacturer with the following particulars:-

a) Grade of cast iron;

b) Identification number, or other marking which will enable the full history of the casting to be traced;

c) Manufacturer's name or trade mark;

d) Designated Authority/Classification Society mark the abbreviated name of the local office of Designated Authority/Classification Society;

e) Personal stamp of the Surveyor responsible for inspection;

f) Where applicable, test pressure;

g) Date of final inspection.

1.11.3 Where small castings are manufactured in large numbers, modified arrangements for identification may be specially agreed with Designated Authority/Classification Society.

### 1.12 Certification

1.12.1 The manufacturer is to provide the Surveyor with a written statement giving the following particulars for each casting or batch of castings which has been accepted:-

a) Purchaser's name and order no;

b) Description of castings and quality of cast iron;

c) Identification number;

d) Results of mechanical tests;

e) Where applicable, details of heat treatment;

f) Where specially required, the chemical analysis of the ladle sample;

g) Where applicable, test pressure.

# Chapter 8

# Copper Alloys

**Contents**

**Section**



## Section 1

## General Requirements

### 1.1 Scope

1.1.1 The requirements in this Chapter apply to copper alloys used in castings for valves and fittings, propeller castings and tubes.

1.1.2 When required by the relevant parts, dealing with design and construction, tubes and castings are to be manufactured and tested in accordance with the appropriate requirements of Ch.1 and 2 and the requirements of this Chapter.

1.1.3 Alternatively, tubes and castings which comply with National or proprietary specifications may be accepted provided these specifications give reasonable equivalence to the requirements of this Chapter and provided that survey is carried out in accordance with the requirements of Ch.1.

1.1.4 Where it is proposed to use an alloy which is not specified in this Chapter, details of chemical composition, heat treatment and mechanical properties are to be submitted for approval.

## Section 2

## Castings for Valves and Fittings

### 2.1 Scope

2.1.1 Following requirements make provision for copper alloy castings for valves, liner bushes and other fittings intended for use in ship and machinery construction.

### 2.2 Manufacture

2.2.1 Approval of Works, as required by Ch.1, for the manufacture of castings, covered by this Section, is not required.

**2.3 Quality of castings**

2.3.1 All castings are to be free from surface or internal defects, which could be prejudicial to their proper application in service.

**2.4 Chemical composition**

2.4.1 The chemical composition is to comply with the appropriate requirements of Table 2.4.1.

2.4.2 Where a cast is wholly prepared from ingots for which an analysis is already available, and provided that no significant alloy additions are made during melting, the ingot maker's certified analysis may be accepted subject to occasional check tests as requested by the Surveyors.

**Table 2.4.1 : Chemical composition**

| Designation | Chemical composition % | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Cu | Sn | Zn | Pb | Ni | Mn | P | Fe | Al |
| 90/10 Cu-Sn Phosphor-bronze | Remainder | 9.0-11.0 | 0.5 max. | 0.75 max. | 0.5 max. | - | 0.50 max. | - | - |
| 85/5/10 Leaded bronze | Remainder | 4.0-6.0 | 2.0 max. | 9.0-11.0 | 2.0 max. | - | 0.10 max. | - | - |
| 88/10/2 Gunmetal | Remainder | 8.5-11.0 | 1.0-3.0 | 1.5 max. | 1.0 max. | - | - | - | - |
| 87/7/3/3 Leaded Gunmetal | Remainder | 6.0-8.0 | 1.5-3.0 | 2.5-3.5 | 2.0 max. | - | - | - | - |
| 85/5/5/5 Leaded Gunmetal | Remainder | 4.0-6.0 | 4.0-6.0 | 4.0-6.0 | 2.0 max. | - | - | - | - |
| 70/30 Cu-Ni-Fe | Remainder | - | - | - | 29.0-32.0 | 0.5-1.50 | - | 0.4-1.0 | - |
| 90/10 Cu-Ni-Fe | Remainder | - | - | - | 9.0-11.0 | 0.5-1.0 | - | 1.0-1.8 | - |
| Ni-Al-bronze | Remainder | 0.10 max. | 1.0 max. | 0.03 max. | 3.0-6.0 | 0.5-4.0 | - | 2.0-6.0 | 7.0-11.0 |

**2.5 Heat treatment**

2.5.1 At the option of the manufacturer castings may be supplied in the 'as cast' or heat treated condition.

**2.6 Mechanical tests**

2.6.1 The test material may be separately cast as a keel block sample in accordance with Fig.3.6.1 or as otherwise agreed with the Surveyor. For liners and bushes, the test material may be cut from the ends of the casting.

2.6.2 Where castings are supplied in a heat treated condition, the test samples are to be similarly heat treated prior to the preparation of the tensile specimens.

2.6.3 The results of all tests are to comply with the appropriate requirements given in Table 2.6.1.

**Table 2.6.1 : Mechanical properties for acceptance purposes**

| Designation | 0.2% proof stress [N/mm$^2$] minimum (see Note) | Tensile Strength [N/mm$^2$] minimum | Elongation on $5.65\sqrt{S_o}$% minimum |
|---|---|---|---|
| 90/10 Cu-Sn Phosphor-bronze | 120 | 250 | 15 |
| 85/5/10 Leaded bronze | 100 | 200 | 16 |
| 88/10/2 Gunmetal | 130 | 270 | 13 |
| 87/7/3/3 Leaded Gunmetal | 130 | 250 | 16 |
| 85/5/5/5 Leaded Gunmetal | 100 | 200 | 16 |
| 70/30 Cu-Ni-Fe | 220 | 420 | 20 |
| 90/10 Cu-Ni-Fe | 160 | 320 | 20 |
| Ni-Aluminium bronze | 240 | 590 | 16 |

Note:

The 0.2% proof stress values are given for information purposes only and, unless otherwise agreed, are not required to be verified by test.

**2.7 Visual examination**

2.7.1 All castings must be supplied in a clean fettled condition.

2.7.2 Before acceptance, all castings are to be presented for visual examination by the Surveyor. This is to include the examination of internal surfaces where applicable.

2.7.3 The accuracy and verification of dimensions are the responsibility of the manufacturer, unless otherwise agreed.

**2.8 Pressure testing**

2.8.1 Where required by the relevant construction Rules, castings are to be pressure tested before final acceptance. Unless otherwise agreed, these tests are to be carried out in the presence of the Surveyors and are to be to their satisfaction.

**2.9 Rectification of defective castings**

2.9.1 Minor surface defects may be removed by grinding provided that the dimensional tolerances are not exceeded.

2.9.2 Proposal to repair a defective casting by welding are to be submitted to the Surveyor for approval before this work is commenced. Such proposals are to include details of the extent and positions of all defects. The Surveyor is to satisfy himself the number and size of the defects are such that castings can be efficiently repaired.

2.9.3 A statement and/or sketch detailing the extent and position of all weld repairs is to be prepared by the manufacturer as permanent record.

2.9.4 Weld repairs to liners in copper alloys containing more than 0.5 per cent lead are not permitted.

**2.10 Identification**

2.10.1 Before acceptance, all castings which have been tested and inspected with satisfactory results are to be clearly marked with the following details:

a) Identification number, cast number or other markings which will enable the full history of the casting to be traced;

b) Brand mark and the abbreviated name of the Designated Authority/Classification Society;

c) Personal stamp of the Surveyor responsible for inspection;

d) Test pressure, where applicable;

e) Date of final inspection.

2.10.2 Where small castings are manufactured in large numbers, modified arrangements for identification may be specially agreed with the Surveyor.

**2.11 Certification**

2.11.1 The manufacturer is to provide the Surveyor with a written statement giving the following particulars for each casting or batch of castings which has been accepted:-

(b) Purchaser's name and order no.;

(c) Description of castings and alloy type;

(d) Identification number

(e) Type of heat treatment, where applicable;

(f) Ingot or cast analysis.

2.11.2 In addition to 2.11.1 the manufacturer is to provide a signed statement and/or sketch detailing the extent and position of all weld repairs made to each casting.

## Section 3

## Castings for Propellers

**3.1 Scope**

3.1.1 These requirements are applicable to the manufacture, inspection and repair procedures of cast copper alloys propellers, blades and bosses.

3.1.2 These requirements may also be used for the repair of propellers damaged in service, subject to prior agreement with Designated Authority/Classification Society

3.1.3 Where the use of alternative alloys is proposed, particulars of chemical composition, mechanical properties and heat treatment are to be submitted for approval.

**3.2 Foundry approval**

3.2.1 Approval

3.2.1.1 All propellers and propeller components are to be manufactured by foundries approved in accordance with Ch.1. Also refer Ch.1, Sec.1, Cl.1.3.2. The castings are to be manufactured and tested in accordance with the requirements of these requirements.

3.2.2 Application for approval

3.2.2.1 It is the manufacturer's responsibility to assure that effective quality, process and production controls during manufacturing are adhered to within the manufacturing specification. The manufacturing specification is to be submitted to Designated Authority/Classification Society at the time of initial approval, and is to at least include the following particulars:

(a) description of the foundry facilities,

(b) copper alloy material specification,

(c) runner and feeder arrangements,

d) manufacturing procedures,

e) non-destructive testing

f) inspection procedures, and

g) repair procedures.

3.2.3 Scope of the approval test

3.2.3.1 The scope of the approval test is to be agreed upon with Designated Authority/Classification Society. This is to include the presentation of cast test coupons of the propeller materials in question for approval testing in order to verify that the chemical composition and the mechanical properties of these materials comply with these requirements.

3.2.4 Inspection facilities

3.2.4.1 The foundry is to have an adequately equipped laboratory, manned by experienced personnel, for the testing of moulding materials chemical analyses, mechanical testing, and microstructural testing of metallic materials and non-destructive testing. Where testing activities are assigned to other companies or other laboratory, additional information required by Designated Authority/Classification Society is to be included.

**3.3. Moulding and casting**

3.3.1 Pouring

3.3.1.1 The pouring is to be carried out into dried moulds using degassed liquid metal. The pouring is to be controlled as to avoid turbulences of flow. Special devices and/or procedures must prevent slag flowing into the mould.

3.3.2 Stress relieving

3.3.2.1 Subsequent stress relieving heat treatment may be performed to reduce the residual stresses. For this purpose, the manufacturer is to submit a specification containing the details of the heat treatment to Designated Authority/Classification Society for approval. For stress relieving temperatures and holding times see Tables 3.12.3(a) and (b).

**3.4 Quality of castings**

3.4.1 Freedom from defects

3.4.1.1 All castings must have a workmanlike finish and are to be free from defects which would be prejudicial to their proper application in service. Minor casting defects which may still be visible after machining such as small sand and slag inclusions, cold shuts and scabs are to be trimmed off by the manufacturer in accordance with 3.11.

3.4.2 Removal of defects

3.4.2.1 Casting defects which may impair the serviceability of the castings, e.g. major non-metallic inclusions, shrinkage cavities, blow holes and cracks, are not permitted. They may be removed by one of the methods described in 3.11 and repaired within the limits and restrictions for the severity zones. Full description and documentation are to be available for the surveyor.

**3.5 Dimensions, dimensional and geometrical tolerances**

3.5.1 The verification of dimensions, the dimensional and geometrical tolerances is the responsibility of the manufacturer. The report on the relevant examinations is to be submitted to the Surveyor, who may require checks to be made in his presence.

3.5.2 Static balancing is to be carried out on all propellers in accordance with the approved drawing. Dynamic balancing is necessary for propellers running above 500 rpm.

**3.6 Chemical composition and metallurgical characteristics**

3.6.1 Chemical composition

3.6.1.1. Typical copper propeller alloys are grouped into the four types CU 1, CU 2, CU 3 and CU 4 depending on their chemical composition as given in Table 3.6.1. Copper alloys whose chemical composition deviate from the typical values of Table 3.6.1 are to be specially approved by Designated Authority/Classification Society. The manufacturer is to maintain records of the chemical analyses of the production casts, which are to be made available to the Surveyor.

3.6.2 Metallurgical characteristics

3.6.2.1 The main constituents of the microstructure in the copper-based alloys categories CU 1 and CU 2 are alpha and beta phase. Important properties such as ductility and resistance to corrosion fatigue are strongly influenced by the relative proportion of beta phase (too high a percentage of beta phase having a negative effect on these properties). To ensure adequate cold ductility and corrosion fatigue resistance, the proportion of beta phase is to be kept low. The concept of the zinc equivalent is to be used as control since it summarizes the effect of the tendency of various chemical elements to produce beta phase in the structure.

3.6.2.2 The structure of CU 1 and CU 2 type alloys must contain an alpha phase component of at least 25 % as measured on a test bar by the manufacturer. The zinc equivalent defined by the following formula is not to exceed a value of 45 %:

$$\text{Zinc equivalent} = 100 - \frac{100 \text{ x } \%\text{Cu}}{100 + \text{A}}$$

where A is the algebraic sum of the following:

1 x % Sn

5 x % Al

- 0.5 x % Mn

- 0.1 x % Fe

- 2.3 x % Ni.

The negative sign in front of the elements Mn, Fe and Ni signifies that these elements tend to reduce the proportion of beta phase.

The micro structure of alloy types CU 1 and CU 2 is to be verified by determining the proportion of alpha phase. For this purpose, at least one specimen is to be taken from each heat. The proportion of alpha phase is to be determined as the average value of 5 counts.

**Table 3.6.1 : Typical chemical compositions of cast copper alloy for propellers**

| **Alloy Designation** | **Chemical composition of ladle samples %** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Cu** | **Sn** | **Zn** | **Pb** | **Ni** | **Fe** | **Al** | **Mn** |
| Grade CU1 Manganese Bronze (high strength brass) | 52 - 62 | 1.5 max. | 35 - 40 | 0.5 max. | 1.0 max. | 0.5-2.5 | 0.5-3.0 | 0.5-4.0 |
| Grade CU2 Ni-Manganese Bronze (high strength brass) | 50 - 57 | 1.5 max. | 33 - 38 | 0.5 max. | 3.0-8.0 | 0.5-2.5 | 0.5-2.0 | 1.0-4.0 |
| Grade CU3 Ni-Aluminium Bronze | 77 - 82 | 0.1 max. | 1.0 max. | 0.03 max. | 3.0-6.0 | 2.0-6.0 | 7.0-11.0 | 0.5-4.0 |
| Grade CU4 Mn - Aluminium Bronze | 70 - 80 | 1.0 max. | 6.0 max. | 0.05 max. | 1.5-3.0 | 2.0-5.0 | 6.5-9.0 | 8.0-20.0 |

**3.7 Mechanical properties and tests**

3.7.1 The mechanical properties are to comply with the values in Table 3.7.1. These values are applicable to test specimens taken from separately cast samples in accordance with Figure 3.7.1 or with a recognised standard.

Note : These properties are a measure of the mechanical quality of the metal in each heat and they are generally not representative of the mechanical properties of the propeller casting itself which may be upto 30% lower than that of a separately cast test coupon. For integrally cast test specimens the requirements are to be specially agreed with Designated Authority/Classification Society.

3.7.2 Other alloys

3.7.2.1 The mechanical properties of alloys not meeting the minimum values of Table 3.7.1 are to comply with a specification approved by Designated Authority/Classification Society.

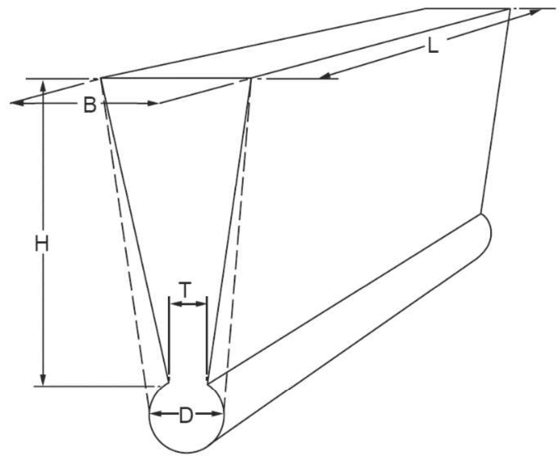
3.7.3 Tensile tests and specimens

3.7.3.1 Tensile tests and specimens are to be in accordance with Ch.2.

3.7.3.2 Generally, the specimens are to be taken from separately cast sample pieces in accordance with 3.7.1. The test samples are to be cast in moulds made of the same material as the mould for the propeller

and they are to be cooled down under the same conditions as the propeller. At least one tensile test specimen is to be taken from each ladle. If propellers are subjected to a heat treatment the test samples are to be heat treated together with them.

3.7.3.3 Where test specimens are to be taken from integrally cast test samples, these are to be the subject of special agreement with Designated Authority/Classification Society. Wherever possible, the test samples are to be located on the blades in an area lying between 0.5 to 0.6 R, where R is the radius of the propeller. The test sample material is to be removed from the casting by non thermal procedures.




H= 100 mm, B=50 mm, L>150 mm, T=15 mm and D = 25 mm

**Fig.3.7.1 : Test sample casting**

**Table 3.7.1 : Mechanical properties of cast copper alloys for propellers ( separately cast test coupons)**

| Alloy Designation | 0.2% proof stress [N/mm$^2$] minimum | Tensile Strength [N/mm$^2$] minimum | Elongation on $5.65\sqrt{S_o}$% minimum |
|---|---|---|---|
| Grade CU1 Manganese bronze | 175 | 440 | 20 |
| Grade CU2 Ni-Manganese bronze | 175 | 440 | 20 |
| Grade CU3 Ni-Aluminium bronze | 245 | 590 | 16 |
| Grade CU4 Mn-Aluminium bronze | 275 | 630 | 18 |

**3.8 Definition of skew, severity zones**

3.8.1 Definition of skew

3.8.1.1 The skew of a propeller is defined as follows:

The maximum skew angle of a propeller blade is defined as the angle, in projected view of the blade, between a line drawn through the blade tip and the shaft centreline and a second line through the shaft centreline which acts as a tangent to the locus of the mid-points of the helical blade section. See Fig.3.8.1.

High skew propellers have a skew angle greater than 25°, low skew propellers a skew angle of up to 25°.

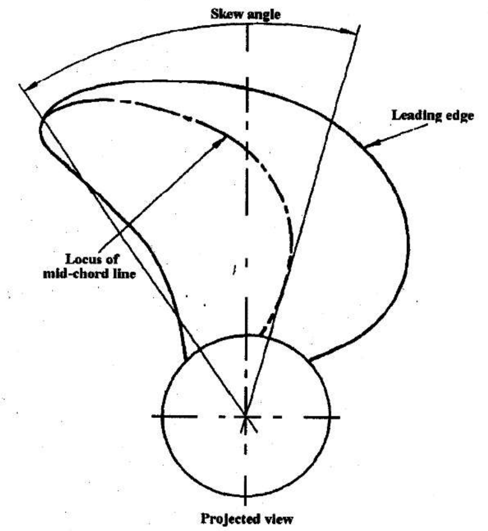



**Fig.3.8.1 : Definition of skew angle**

**3.8.2 Severity zones**

In order to relate the degree of inspection to the criticality of defects in propeller blades and to help reduce the risk of failure by fatigue cracking after repair, propeller blades are divided into the three severity zones designated A, B and C.

Zone A is the region carrying the highest operating stresses and which, therefore, requires the highest degree of inspection. Generally, the blade thicknesses are greatest in this area giving the greatest degree of restraint in repair welds and this in turn leads to the highest residual stresses in and around any repair welds. High residual tensile stresses frequently lead to fatigue cracking during subsequent service so that relief of these stresses by heat treatment is essential for any welds made in this zone. Welding is generally not permitted in Zone A and will only be allowed after special consideration. Every effort is to be made to rectify a propeller which is either defective or damaged in this area without recourse to welding even to the extent of reducing the scantlings, if this is acceptable. If a repair using welding is agreed, postweld stress relief heat treatment is mandatory.

Zone B is a region where the operating stresses may be high. Welding is to preferably be avoided but generally is allowed subject to prior approval from Designated Authority/Classification Society. Complete details of the defect / damage and the intended repair procedure are to be submitted for each instance in order to obtain such approval.

Zone C is a region in which the operating stresses are low and where the blade thicknesses are relatively small so that repair welding is safer and, if made in accordance with an approved procedure is freely permitted.

3.8.2.1 Low-skew propellers

Zone A is in the area on the pressure side of the blade, from and including the fillet to 0.4R, and bounded on either side by lines at a distance 0,15 times the chord length Cr from the leading edge and 0.2 times Cr from the trailing edge, respectively (see Fig. 3.8.2).Where the hub radius (Rb) exceeds 0.27R, the other boundary of zone A is to be increased to 1.5Rb.

Zone A also includes the parts of the separate cast propeller hub which lie in the area of the windows as described in Fig. 3.8.4 and the flange and fillet area of controllable pitch and built-up propeller blades as described in Fig. 3.8.5.

Zone B is on the pressure side the remaining area up to 0.7R and on the suction side the area from the fillet to 0.7R (see Fig. 3.8.1).

Zone C is the area outside 0.7R on both sides of the blade. It also includes the surface of the hub of a monoblock propeller and all the surfaces of the hub of a controllable pitch propeller other than those designated Zone A above.

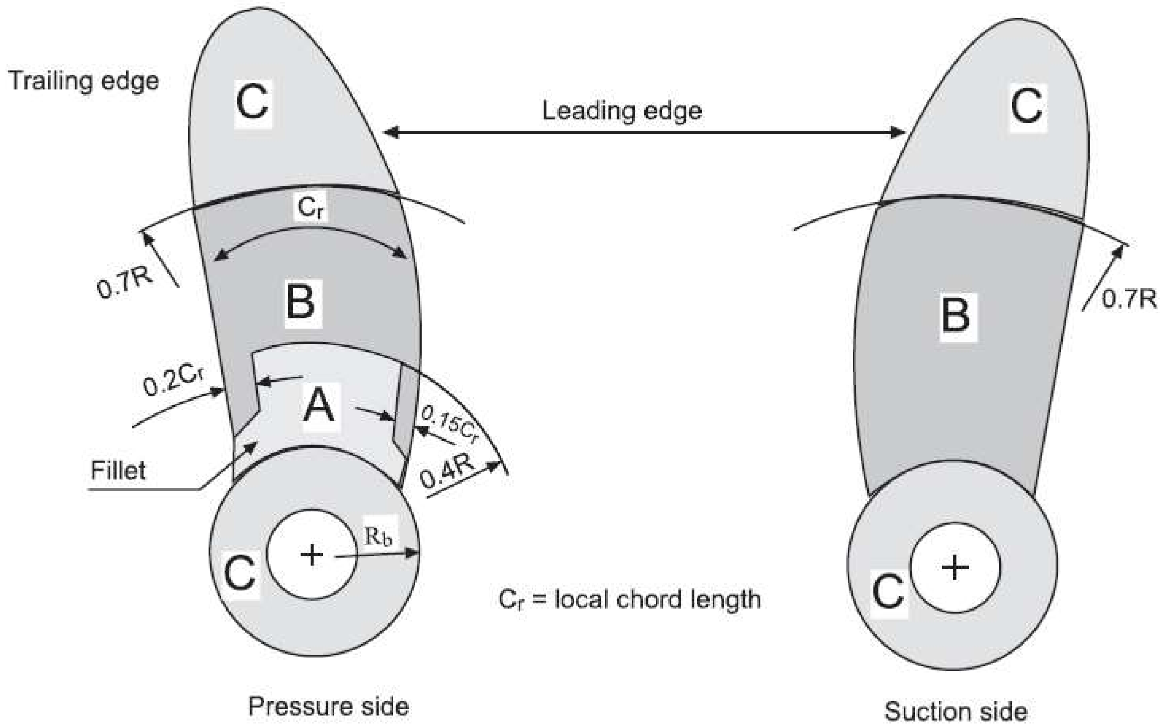



**Fig.3.8.2 : Severity zones for integrally cast low skew propellers**

3.8.2.2 High-skew propellers

Zone A is the area on the pressure face contained within the blade root-fillet and a line running from the junction of the leading edge with the root fillet to the trailing edge at 0.9 R and at passing through the mid-point of the blade chord at 0.7 R and a point situated at 0.3 of the chord length from the leading edge at 0.4 R. It also includes an area along the trailing edge on the suction side of the blade from the root to 0.9 R and with its inner boundary at 0.15 of the chord lengths from the trailing edge. Zone B constitutes the whole of the remaining blade surfaces. Zone A and B are illustrated in Fig. 3.8.3.

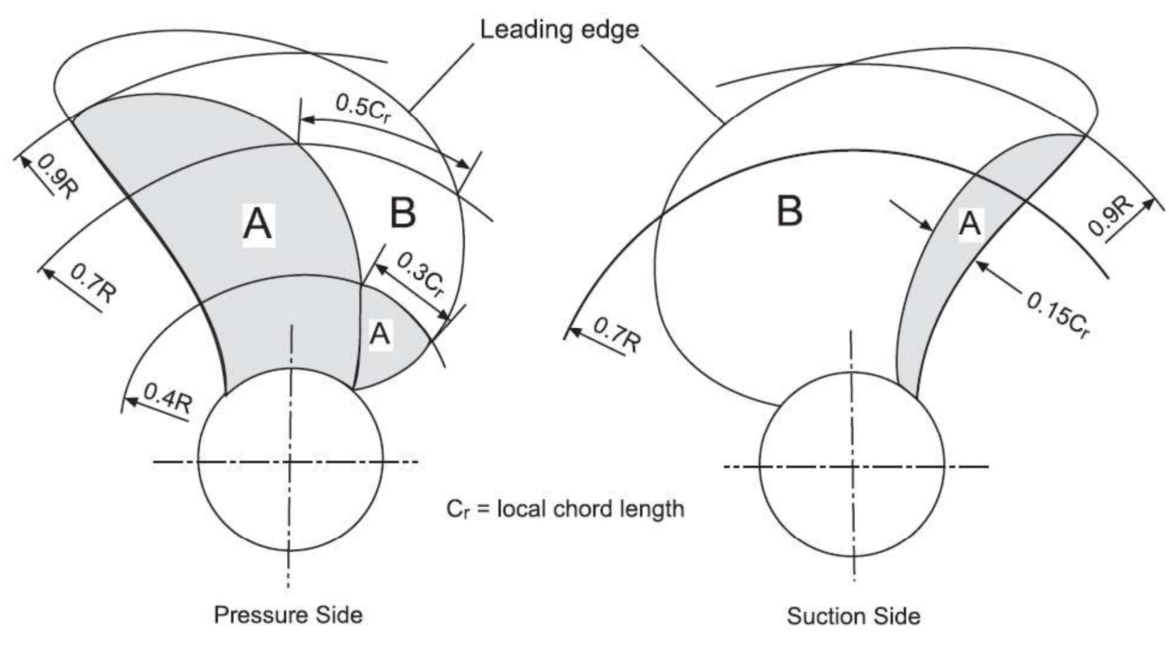


**Fig.3.8.3 : Severity zones in blades with skew angles greater than 25°**

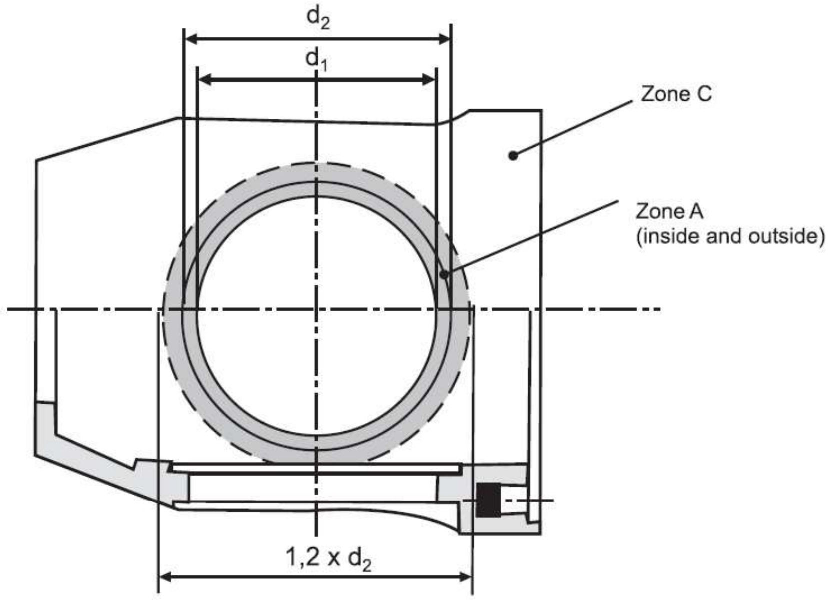



**Fig.3.8.4 : Severity zones for controllable pitch propeller boss**

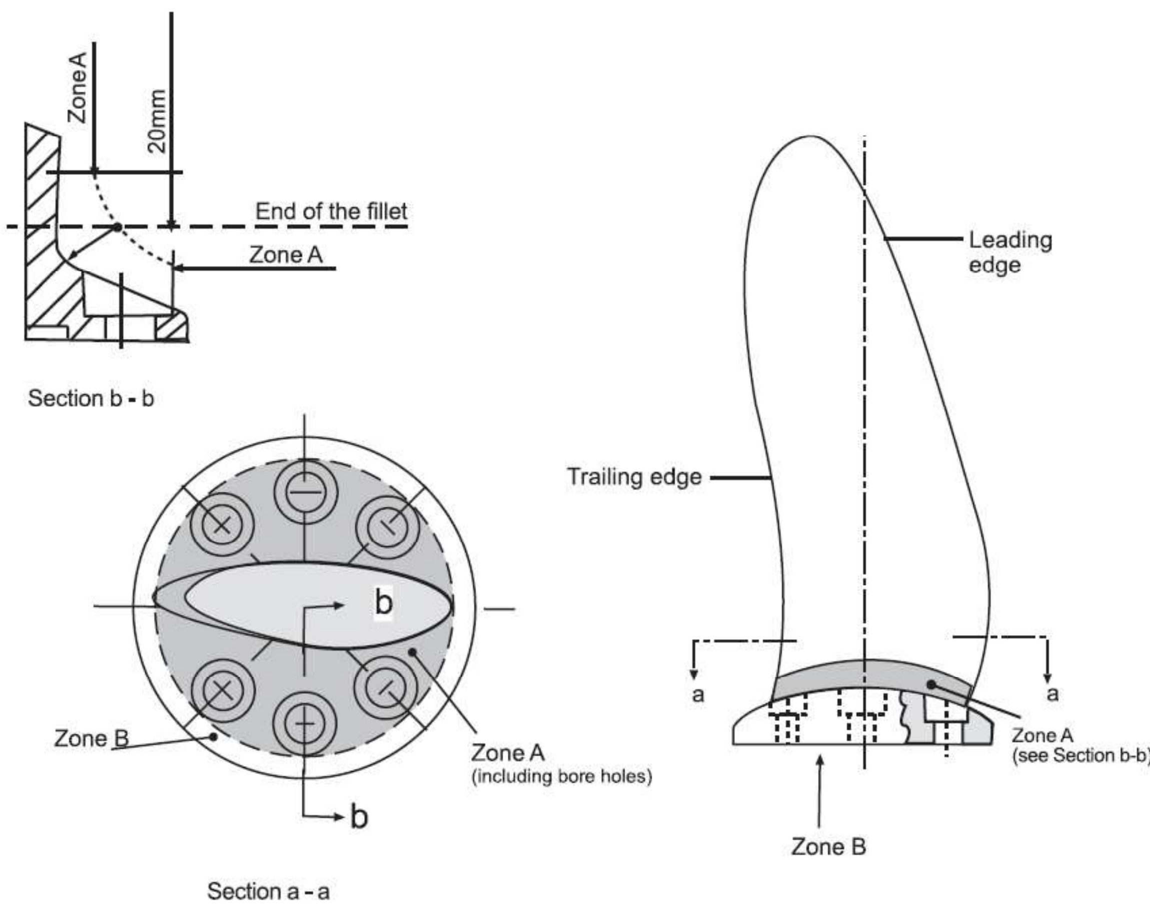



**Fig.3.8.5 : Severity zones for controllable pitch and built-up propeller**

**Note:**

The remaining surface of the propeller blades is to be divided into the severity zones as given for solid cast propellers (Fig. 3.8.2 and Fig. 3.8.3)

**3.9 Non-destructive testing**

3.9.1 Qualification of personnel involved in NDT

3.9.1.1 personnel involved in NDT are to be qualified according to the requirements of the Designated Authority/Classification Society.

3.9.2 Visual testing

3.9.2.1 All finished castings are to be 100% visually inspected by the manufacturer. Castings are to be free from cracks, hot tears or other imperfections which, due to their nature, degree or extent, will interfere with the use of the castings. A general visual examination is to be carried out by the Surveyor.

3.9.3 Liquid penetrant testing

3.9.3.1 Liquid penetrant testing procedure is to be submitted to Designated Authority/Classification Society and is to be in accordance with ISO 3452-1:2013 or a recognized standard. The acceptance criteria are specified in 3.10. The severity zone A is to be subjected to a liquid penetrant testing in the presence of the Surveyor.

In zones B and C the liquid penetrant testing is to be performed by the manufacturer and may be witnessed by the Surveyor upon his request. If repairs have been made either by grinding, straightening or by welding the repaired areas are additionally to be subjected to the liquid penetrant testing independent of their location and/or severity zone.

3.9.4 Radiographic and ultrasonic testing

3.9.4.1 When required by Designated Authority/Classification Society or when deemed necessary by the manufacturer, further non-destructive testing (e.g. radiographic and/or ultrasonic testing) are to be carried out. The acceptance criteria or applied quality levels are to be agreed between the manufacturer and Designated Authority/Classification Society in accordance with a recognized standard.

Note: due to the attenuating effect of ultrasound within cast copper alloys, ultrasonic testing may not be practical in some cases, depending on the shape/type/thickness, and grain-growth direction of the casting.

In such cases, effective ultrasound penetration into the casting is to be practically demonstrated on the item. This would normally be determined by way of back-wall reflection, and/or target features within the casting.

**3.10 Acceptance criteria for liquid penetrant testing**

**3.10.1 Definitions of liquid penetrant indications**

**Indication:** In the liquid dye penetrant inspection testing an indication is the presence of detectable bleed-out of the penetrant liquid from the material discontinuities appearing at least 10 minutes after the developer has been applied.

**Relevant indication:** Only indications which have any dimension greater than 1.5 mm are to be considered relevant for the categorization of indications.

**Non-linear indication:** an indication with a largest dimension less than three times its smallest dimension (i.e. $l < 3$ w).

**Linear indication:** an indication with a largest dimension three or more times its smallest dimension (i.e. $l \geq 3$ w).

**Aligned indications:**

a) Non-linear indications form an alignment when the distance between indications is less than 2 [mm] and at least three indications are aligned. An alignment of indications is considered to be a unique indication and its length is equal to the overall length of the alignment.

b) Linear indications form an alignment when the distance between two indications is smaller than the length of the longest indication.

Illustration of liquid penetrant indication is given in Fig. 3.10.1.

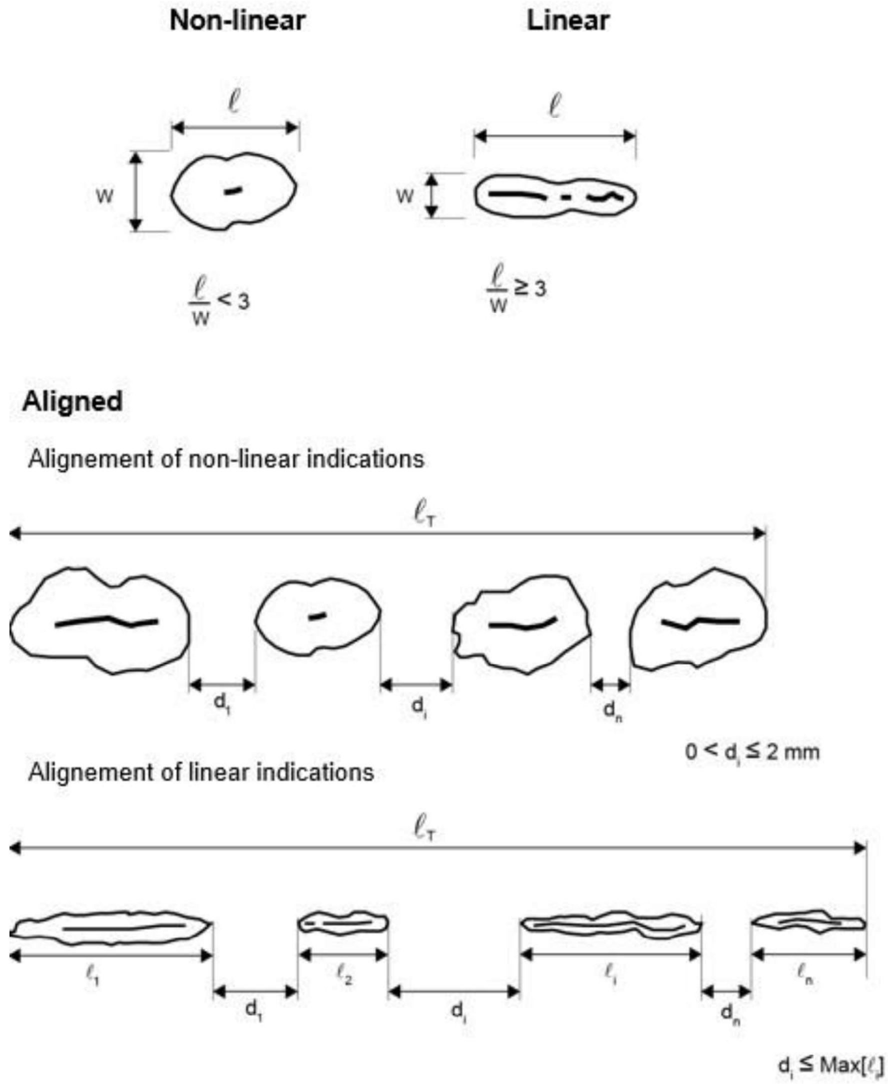



**Fig.3.10.1 : Shape of indications**

**Table 3.10.2 : Allowable number and size of relevant indications in a reference area of 100 [cm²], depending on severity zones[1)]**

| Severity zones | Max. total number of indications | Type of indication | Max. number of each type [1)2)] | Max. acceptable value for "a" or "l" of indications [mm] |
|---|---|---|---|---|
| A | 7 | Non-Linear | 5 | 4 |
| | | Linear | 2 | 3 |
| | | Aligned | 2 | 3 |
| B | 14 | Non-Linear | 10 | 6 |
| | | Linear | 4 | 6 |
| | | Aligned | 4 | 6 |
| C | 20 | Non-Linear | 14 | 8 |
| | | Linear | 6 | 6 |
| | | Aligned | 6 | 6 |

**Notes:**

1) Singular non-linear indications less than 2 [mm] for zone A and less than 3 [mm] for the other zones are not considered relevant.
2) The total number of non-linear indications may be increased to the max. total number, or part thereof, represented by the absence of linear or aligned indications.

**3.10.2 Acceptance standard**

3.10.2.1 The surface to be inspected is to be divided into reference areas of 100 [cm$^2$] . Each reference area may be square or rectangular with the major dimension not exceeding 250mm.

The area is to be taken in the most unfavourable location relative to the indication being evaluated.

The relevant indications detected, with respect to their size and number, are not to exceed the values given in the Table 3.10.2.

3.10.2.2 Areas which are prepared for welding are, independent of their location, always to be assessed according to Zone A. The same applies to the welded areas after being finished machined and/or ground.

**3.11 Repair of defects**

3.11.1 Definitions

3.11.1.1 Indications exceeding the acceptance standard of Table 3.10.2, cracks, shrinkage cavities, sand, slag and other non-metallic inclusions, blow holes and other discontinuities which may impair the safe service of the propeller are defined as defects and must be repaired.

3.11.2 Repair procedures

a) In general the repairs are to be carried out by mechanical means, e.g. by grinding, chipping or milling. Welding may be applied subject to the agreement with Designated Authority/Classification Society if requirements of 3.11.3, 3.11.4 and/or 3.11.5 will be complied with.

b) After milling or chipping grinding is to be applied for such defects which are not to be welded. Grinding is to be carried out in such a manner that the contour of the ground depression is as smooth as possible in order to avoid stress concentrations or to minimise cavitation corrosion. Complete elimination of the defective material is to be verified by liquid penetrant testing.

c) Welding of areas less than 5 [cm$^2$] is to be avoided.

3.11.3 **Repair of defects in zone A**

a) In zone A, repair welding will generally not be allowed unless specially approved by Designated Authority/Classification Society. In some cases the propeller designer may submit technical documentation to propose a modified zone A based on detailed hydrodynamic load and stress analysis for consideration by Designated Authority/Classification Society.

b) Grinding may be carried out to an extent which maintains the blade thickness of the approved drawing.

c) The possible repair of defects which are deeper than those referred to above will be specially considered by Designated Authority/Classification Society.

3.11.4 **Repair of defects in zone B**

a) Defects that are not deeper than dB = (t/40) [mm] (t = minimum local rule thickness [mm]) or 2 [mm] (whichever is greater) below minimum local rule thickness is to be removed by grinding.

b) Those defects that are deeper than allowable for removal by grinding may be repaired by welding.

3.11.5 **Repair of defects in zone C**

In zone C, repair welds are generally permitted.

3.11.6 **Repair documentation**

3.11.6.1 The foundry is to maintain records of inspections, welding, and any subsequent heat treatment, traceable to each casting. Before welding is started, full details of the extent and location of the repair, the proposed welding procedure, heat treatment and subsequent inspection procedures are to be submitted to Designated Authority/Classification Society for approval.

**3.12 Welding repair procedure**

3.12.1 General requirements

3.12.1.1 Before welding is started, manufacturer is to submit to Designated Authority/Classification Society a detailed welding procedure specification covering the weld preparation, welding parameters, filler metals, preheating and post weld heat treatment and inspection procedures.

3.12.1.2 All weld repairs are to be carried out in accordance with qualified procedures, and, by welders who are qualified to a recognized standard. Welding Procedure Qualification Tests are to be carried out in accordance with 3.16 and witnessed by the Surveyor.

3.12.2 Defects to be repaired by welding are to be ground to sound material according to 3.11.2.

3.12.2.1 The welding grooves are to be prepared in such a manner which will allow a good fusion of the groove bottom. The resulting ground areas are to be examined in the presence of the Surveyor by liquid penetrant testing in order to verify the complete elimination of defective material.

3.12.3 Welding repair procedure

3.12.3.1 Metal arc welding is recommended to be used for all types of welding repair on cast copper alloy propellers.

Arc welding with coated electrodes and gas-shielded metal arc process (GMAW) are generally to be applied. Argon-shielded tungsten welding (GTAW) is to be used with care due to the higher specific heat input of this process.

Recommended filler metals, pre-heating and stress relieving temperatures are listed in Table 3.12.3(a).

3.12.3.2 All propeller alloys are generally to be welded in down-hand (flat) position. Where this cannot be done, gas-shielded metal arc welding is to be carried out.

The section to be welded is to be clean and dry. Flux-coated electrodes are to be dried before welding according to the maker's instructions.

To minimize distortion and the risk of cracking, interpass temperatures are to be kept low especially in the case of CU3 alloys.

Slag, undercuts and other defects are to be removed before depositing the next run.

**Table 3.12.3(a) : Recommended filler metals and heat treatments**

| Alloy type | Filler metal | Preheat temp.°C [min] | Interpass temp.°C [max] | Stress relief temp.°C | Hot straightening temp.°C |
|---|---|---|---|---|---|
| CU1 | Al-bronze [1)]<br>Mn-bronze | 150 | 300 | 350 - 500 | 500 - 800 |
| CU2 | Al-bronze<br>Ni-Mn-bronze | 150 | 300 | 350 - 550 | 500 - 800 |
| CU3 | Al-bronze<br>Ni-Al-bronze [2)]<br>Mn-Al-bronze | 50 | 250 | 450 - 500 | 700 - 900 |
| CU4 | Mn-Al-bronze | 100 | 300 | 450 - 600 | 700 - 850 |

**Notes:**

1) Ni-Al-bronze and Mn-Al-bronze are acceptable.

2) Stress relieving not required, if filler metal Ni-Al-bronze is used.

**Table 3.12.3(b) : Soaking times for stress relief heat treatment of copper alloy propellers**

| Stress relief temp.°C | Alloy grade CU1 and CU2 | | Alloy grade CU3 and CU4 | |
|---|---|---|---|---|
| | Hours per 25 [mm] thickness | Max. recommended total time hours | Hours per 25 [mm] thickness | Max. recommended total time hours |
| 350 | 5 | 15 | - | - |
| 400 | 1 | 5 | - | - |
| 450 | 1/2 | 2 | 5 | 15 |
| 500 | 1/4 | 1 | 1 | 5 |
| 550 | 1/4 | 1.2 | 1/2 [1)] | 2 [1)] |
| 600 | - | - | 1/4 [1)] | 1 [1)] |

Note 1) 550°C and 600°C only applicable for CU4 alloys

3.12.3.3 All welding work is to be carried out preferably in the shop free from draughts and influence of the weather.

3.12.3.4 With the exception of alloy CU3 (Ni-Al-bronze) all weld repairs are to be stress relief heat treated, in order to avoid stress corrosion cracking. However, stress relief heat treatment of alloy CU3 propeller castings may be required after major repairs in zone B (and specially approved welding in Zone A) or if a welding consumable susceptible to stress corrosion cracking is used. In such cases the propeller is to be either stress relief heat treated in the temperature 450 to 500°C or annealed in the temperature range 650 - 800°C, depending on the extent of repair, see Table 3.12.3(a).

3.12.3.5 The soaking times for stress relief heat treatment of copper alloy propellers is to be in accordance with Table 3.12.3(b). The heating and cooling is to be carried out slowly under controlled conditions. The cooling rate after any stress relieving heat treatment is not to exceed 50°C/hr until the temperature of 200°C is reached.

**3.13 Straightening**

3.13.1 **Application of load**

For hot and cold straightening purposes, static loading only is to be used.

3.13.2 **Hot straightening**

Weld repaired areas may be subject to hot straightening, provided it can be demonstrated that weld properties are not impaired by the hot straightening operations.

Straightening of a bent propeller blade or a pitch modification is to be carried out after heating the bent region and approximately 500 [mm] wide zones on either side of it to the suggested temperature range given in Table 3.12.3.(a).

The heating is to be slow and uniform and the concentrated flames such as oxy-acetylene and oxy-propane are not to be used. Sufficient time is be allowed for the temperature to become fairly uniform through the full thickness of the blade section. The temperature is to be maintained within the suggested range throughout the straightening operation. A thermocouple instrument or temperature indicating crayons are to be used for measuring the temperature.

3.13.3 **Cold straightening**

Cold straightening is to be used for minor repairs of tips and edges only. Cold straightening on CU1, CU2 and CU4 bronze is always to be followed by a stress relieving heat treatment, See Table 3.12.3(a).

**3.14 Identification and marking**

3.14.1 Identification

3.14.1.1 The manufacturer is to adopt a system for the identification of all castings, which enable the material to be traced to its original cast. The Surveyor is to be given full facilities for so tracing the castings when required.

3.14.2 Marking

3.14.2.1 Each finished casting propeller is to be marked by the manufacturer at least with the following particulars:

a) Grade of cast material or corresponding abbreviated designation

b) Manufacturer's mark

c) Heat number, casting number or another mark enabling the manufacturing process to be traced back

d) Date of final inspection

e) Designated Authority/Classification Society certificate number

f) Ice class symbol, where applicable

g) Skew angle for high skew propellers.

**3.15 Manufacturer's Certificates**

3.15.1 For each casting propeller the manufacturer is to supply to the Surveyor a certificate containing the following details:

a) Purchaser and order number

b) Shipbuilding project number, if known

c) Description of the casting with drawing number

d) Diameter, number of blades, pitch, direction of turning

e) Grade of alloy and chemical composition of each heat

f) Heat or casting number

g) Final weight

h) Results of non-destructive tests and details of test procedure where applicable

i) Portion of alpha-structure for CU 1 and CU 2 alloys

k) Results of the mechanical tests

l) Casting identification Number.

m) Skew angle for high skew propellers, see 3.8.1.

**3.16 Welding procedure qualification tests for repair of cast copper alloy propeller**

3.16.1 General

3.16.1.1 This sub-section includes the requirements for qualification tests of welding procedures intended for the repair of cast copper alloy propellers.

3.16.1.2 For the welding procedure approval the welding procedure qualification tests are to be carried out with satisfactory results. The qualification tests are to be carried out with the same welding process, filler metal, preheating and stress-relieving treatment as those intended applied by the actual repair work. Welding procedure specification (WPS) is to refer to

the test results achieved during welding procedure qualification testing.

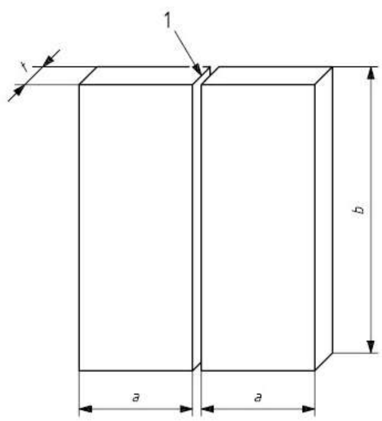
3.16.1.3 Welding procedures qualified at a manufacturer are valid for welding in workshops under the same technical and quality management.

3.16.2 Test piece and welding of sample

3.16.2.1 The test assembly, consisting of cast samples, is to be of a size sufficient to ensure a reasonable heat distribution and according to Fig. 3.16.2.1 with the minimum dimensions. A test sample of minimum 30 mm thickness is to be used.

3.16.2.2 Preparation and welding of test pieces are to be carried out in accordance with the general condition of repair welding work which it represents.

3.16.2.3 Welding of the test assemblies and testing of test specimens are to be witnessed by the Surveyor.




1: Joint preparation and fit-up as detailed in the preliminary welding procedure specification

a: minimum value 150mm

b: minimum value 300mm

t: material thickness.

**Fig.3.16.2.1 : Test piece for welding repair procedure**

3.16.3 Examination and tests

3.16.3.1 Test assembly is to be examined non-destructively and destructively in accordance with the Table 3.16.3.1 and Fig. 3.16.3.1.

**Table 3.16.3.1 : Type of tests and extent of testing**

| **Type of test 1)** | **Extent of testing** |
|---|---|
| Visual testing | 100% as per 3.16.2 |
| Liquid penetrant testing | 100% as per 3.16.2 |
| Transverse tensile test | Two specimens as per 3.16.3 |
| Macro examination | Three specimens as per 3.16.4 |
| Note 1: bend or fracture test are at the discretion of Designated Authority/Classification Society. | |

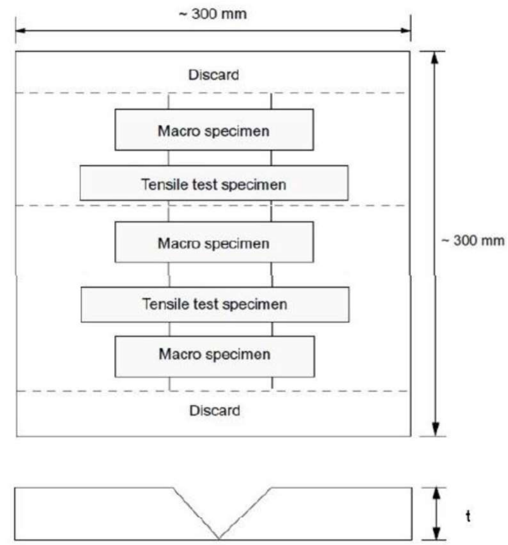



**Fig.3.16.3.1 : Test Specimen**

3.16.3.2 Non-destructive testing

.1 The test assembly is to be examined by visual and liquid penetrant testing prior to the cutting of test specimen. In case, that any post-weld heat treatment is required or specified, non-destructive testing is to be performed after heat treatment. No cracks are permitted. Imperfections detected by liquid penetrant testing are to be assessed in accordance with 3.10.

3.16.3.3 Tensile test:

.1 Two tensile tests are to be prepared as shown in Ch.2. Alternatively tensile test specimens according to recognized standards acceptable to Designated Authority/Classification Society may be used. The tensile strength is to meet the values given in Table 3.16.3.3.

3.16.3.4 Macroscopic examination

Three test specimens are to be prepared and etched on one side to clearly reveal the weld metal, the fusion line and the heat affected zone (Figure 3.16.3.1). A suitable etchant for this purpose is:

5 g iron (III) chloride

30 ml hydrochloric acid (cone)

100 ml water.

The test specimens are to be examined for imperfections present in the weld metal and the heat affected zone. Cracks and lack of fusion are not permitted. Imperfections such as

pores, or slag inclusions, greater than 3 [mm] are not permitted.

**Table 3.16.3.3 : Required tensile strength values**

| Alloy Type | Tensile strength [N/mm$^2$] min |
|---|---|
| CU 1 | 370 |
| CU 2 | 410 |
| CU 3 | 500 |
| CU 4 | 550 |

3.16.3.5 Re-testing

.1 If the test piece fails to comply with any of the requirements for visual or non-destructive testing one further test piece is to be welded and subjected to the same examination. If this additional test piece does not comply with the relevant requirements, the pWPS (preliminary welding procedure specification) is to be regarded as not capable of complying with the requirements without modification.

.2 If any test specimens fail to comply with the relevant requirements for destructive testing due to weld imperfections only, two further test specimens are to be obtained for each one that failed. These specimens can be taken from the same test piece if there is sufficient material available or from a new test piece, and are to be subjected to the same test. If either of these additional test specimens does not comply with the relevant requirements, the pWPS is to be regarded as not capable of complying with the requirements without modification.

.3 If a tensile test specimen fails to meet the requirements, the re-testing is to be in accordance with Ch.2.

.4 If there is a single hardness value above the maximum values allowed, additional hardness tests are to be carried out (on the reverse of the specimen or after sufficient grinding of the tested surface). None of the additional hardness values is to exceed the maximum hardness values required.

.5 The re-testing of Charpy impact specimens are to be carried out in accordance with Ch.2.

.6 Where there is insufficient welded assembly remaining to provide additional test specimens, a further assembly is to be welded using the same procedure to provide the additional specimens.

**3.16.4 Test record**

3.16.4.1 Welding conditions for test assemblies and test results are to be recorded in welding procedure qualification record. Forms of welding procedure qualification records may be in accordance with recognised standards.

3.16.4.2 A statement of the results of assessing each test piece, including repeat tests, is to be made for each welding procedure qualification records. The relevant items listed for the WPS are to be included.

3.16.4.3 The welding procedure qualification record is to be signed by the Surveyor witnessing the test and is to include the IR identification.

**3.16.5 Range of approval**

3.16.5.1 General

.1 All the conditions of validity stated below are to be met independently of each other. Changes outside of the ranges specified are to require a new welding procedure test. A qualification of a WPS obtained by a manufacturer is valid for welding in workshops or sites under the same technical and quality control of that manufacturer.

3.16.5.2 Base metal

.1 The range of qualification related to base metal is given in Table 3.16.5.2.

**Table 3.16.5.2 : Range of qualification for base metal**

| **Copper alloy material grade used for qualification** | **Range of approval** |
|---|---|
| CU1 | CU1 |
| CU2 | CU1& CU2 |
| CU3 | CU3 |
| CU4 | CU4 |

3.16.5.3 Thickness

.1 The qualification of a WPS carried out on a weld assembly of thickness t is valid for the thickness range given in Table 3.16.5.3.

**Table 3.16.5.3 : Range of qualification for thickness**

| **Thickness of the test piece, t (mm)** | **Range of approval** |
|---|---|
| $30 \leq t$ | $\geq 3$ mm |

3.16.5.4 Welding position

.1 Approval for a test made in any position is restricted to that position.

3.16.5.5 Welding process

.1 The approval is only valid for the welding process used in the welding procedure test. Single run is not qualified by multi-run butt weld test used in this section

3.16.5.6 Filler metal

.1 The approval is only valid for the filler metal used in the welding procedure test.

3.16.5.7 Heat input

.1 The upper limit of heat input approved is 25% greater than that used in welding the test piece. The lower limit of heat input approved is 25% lower than that used in welding the test piece.

3.16.5.8 Preheating and interpass temperature

.1 The minimum preheating temperature is not to be less than that used in the qualification test. The maximum interpass temperature is not to be higher than that used in the qualification test.

3.16.5.9 Post-weld heat treatment

The heat treatment used in the qualification test is to be specified in pWPS. Soaking time may be adjusted as a function of thickness.

## Section 4

## Tubes

### 4.1 Scope

4.1.1 Following requirements make provision for copper and copper alloy tubes intended for use in heat exchangers, condensers and pressure piping systems.

4.1.2 Except for pipes for Class lll pressure systems (as defined in Annex 3, Ch.2) all pipes and tubes are to be manufactured and tested in accordance with the requirements of Ch.1 and 2 of this Part and the requirements of this Section.

4.1.3 Pipes and tubes which comply with national/international or proprietary specifica-ions may be accepted provided that these specifications give reasonable equivalence to the requirements of this Section or are otherwise specifically approved for a specific application and provided that survey is carried out in accordance with Ch.1 of this Annex.

4.1.4 At the discretion of the Surveyor, modified testing procedure may be adopted for small quantities of materials. In such cases, these may be accepted on the manufacturer's declared chemical composition and hardness tests or other evidence of satisfactory properties.

4.1.5 Pipes for Class lll pressure systems are to be manufactured and tested in accordance with the requirements of an acceptable national/ international specification. The manufacturer's test certificate will be acceptable and is to be provided for each consignment of material.

### 4.2 Manufacture

4.2.1 Approval of Works, as required by Ch.1, for the manufacture of copper and copper alloy tubes is generally not required.

4.2.2 Unless otherwise agreed tubes shall be solid drawn.

### 4.3 Quality

4.3.1 Tubes are to have a workmanlike finish and are to be clean and free from such surface and internal defects as can be established by the specified tests.

4.3.2 The tubes are to be supplied in straight lengths, and the ends are to be cut clean and square with the axis of the tube.

4.3.3 The tolerance on wall thickness and diameter of pipes and tubes are to be in accordance with an acceptable national/ international standard.

### 4.4 Chemical composition

4.4.1 The chemical analysis is to comply with the requirements of Table 4.4.1. Residual elements are not to be present in amounts greater than specified in an acceptable national/international standard.

### 4.5 Heat treatment

4.5.1 All tubes are to be supplied in the annealed condition. Aluminium brass tubes may additionally be required to be given a suitable stress relieving heat treatment when subjected to a cold straightening operation after annealing.

### 4.6 Mechanical tests

4.6.1 The tubes are to be presented in lots of 600 tubes or 900 [Kg], whichever is greater. Each lot is to contain tubes of the same dimensions, material grade and in the same state of heat treatment. From each lot 2 tubes are to be selected for testing.

4.6.2 Following tests are to be carried out on each tube selected for testing in accordance with the requirements of Ch.2:

a) Tensile test;

b) Flattening test;

c) Drift Expanding test.

4.6.3 Flattening test is to be carried out until the interior surfaces of the tube meet.

4.6.4 For the drift-expanding test, the mandrel is to have an included angle of 45°.

4.6.5 The results of all mechanical tests are to comply with the requirements of Table 4.6.1.

| Table 4.4.1 : Chemical composition of tubes [1] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Designation** | **Chemical composition %** | | | | | | | | |
| | **Cu** | **Fe** | **Ni** | **Zn** | **As** | **Al** | **Mn** | **P** | **Pb** |
| Phosphorus deoxidised non-arsenical copper | 99.90 [2] min. | - | - | - | - | - | - | 0.013-0.050 | - |
| Phosphorus deoxidised arsenical copper | 99.20 [2] min. | - | - | - | 0.30-0.50 | - | 0.013-0.050 | - | - |
| Al-brass | 76.0-79.0 | - | - | Remainder | 0.02-0.06 | 1.8-2.3 | - | - | - |
| Copper-nickel 90/10 | Remainder | 1.0-1.8 | 9.0-11.0 | - | - | - | 0.5-1.0 | - | - |
| Copper-nickel 70/30 | Remainder | 0.4-1.0 | 30.0-32.0 | - | - | - | 0.5-1.5 | - | - |

Notes:

1) Table shows essential alloying elements only

2) Includes silver also.

| Table 4.6.1 : Mechanical properties for acceptance purposes | | | | |
|---|---|---|---|---|
| **Designation** | **0.2% proof stress [N/mm$^2$] minimum** | **Tensile strength [N/mm$^2$] minimum** | **$5.65\sqrt{S_o}$% minimum** | **Drift expansion test % minimum** |
| Phosphorus deoxidised non-arsenical copper | 100 | 220 | 35 | 30 |
| Phosphorus deoxidised arsenical copper | 100 | 220 | 35 | 30 |
| Al-brass | 110 | 320 | 35 | 30 |
| Copper-nickel 90/10 | 100 | 270 | 30 | 30 |
| Copper-nickel 70/30 | 120 | 360 | 30 | 30 |

**4.7 Visual examination**

4.7.1 All pipes are to be presented for visual examination and verification of dimensions. The manufacturer is to provide adequate lighting conditions to enable an internal and external examination of the tubes to be carried out.

**4.8 Stress cracking test**

4.8.1 This test is applicable to aluminium brass only. Mercurous Nitrate Test or alternatively at the express agreement between purchaser and manufacturer Ammonia Vapour Cracking Test are to be carried out on test specimen to prove that the tubes are free from internal stresses. The tests are to be carried out in accordance with an acceptable national/international standard.

4.8.2 Should a specimen reveal cracks when tested, the manufacturing batch shall be rejected. The manufacturer shall be free to submit the batch to renewed heat treatment before presenting it for retesting.

**4.9 Hydraulic test**

4.9.1 All tubes are to be hydraulically tested by the manufacturer to the following pressure:

$$P = \frac{5 \text{ x } t \text{ x } Rm}{D}$$

where,

P = Test pressure;

t = nominal wall thickness;

D = nominal outside diameter;

Rm = Tensile strength in accordance with Table 4.6.1.

Unless otherwise stated the pressure need not be greater than 7.0 [N/mm$^2$].

4.9.2 The test pressure is to be maintained for sufficient time to permit proof and inspection. Unless otherwise agreed, the manufacturer's certificate of satisfactory hydraulic test will be accepted subject to 10 per cent of the tubes being retested in the presence of the Surveyor. If one of the tubes in a batch does not pass the test, it will be rejected, and all other tubes in the batch are to be retested.

**4.10 Identification**

4.10.1 Tubes are to be clearly marked by the manufacturer in accordance with the requirements of Ch.1, with at least the following details:

a) Designated Authority/Classification Society mark

b) Manufacturer's name or trade mark;

c) Grade of material.

4.10.2 Identification is to be by rubber stamp or stencil. Hard stamping is not to be used.

**4.11 Certification**

4.11.1 The manufacturer is to provide the Surveyor with a written statement giving the following particulars for each lot of material accepted:-

a) Purchaser's name and Order no.;

b) Grade of material;

c) Description and dimensions;

d) Cast number and chemical composition;

e) Mechanical test results and results of stress cracking tests where applicable.

# Chapter 9

# Aluminium Alloys

**Contents**



## Section 1

## General

**1.1 Scope**

1.1.1 This Chapter specifies the requirements for wrought aluminium alloys for structural applications, aluminium alloy castings and aluminium/steel transition joints intended for use in ship and machinery construction.

1.1.2 This Chapter is not applicable to aluminium alloys for forgings and to the use of aluminium alloys at low temperature for cryogenic applications. For these products suitable alloys which comply with recognized standards may be used.

1.1.3 These requirements are applicable to wrought aluminium alloy products within a thickness range of 3 [mm] and 50 [mm] inclusive. The application of aluminium alloys products outside this thickness range requires prior agreement of Designated Authority/Classification Society.

1.1.4 The numerical designation (grade) of aluminium alloys and the temper designation are based on those of the Aluminium Association.

Temper conditions (delivery heat treatment) are as defined in EN 515:2017 Or ANSI H35.1:2017.

1.1.5 When required by the relevant Chapters of the Rules dealing with design and construction, structural aluminium alloys, aluminium alloy castings and aluminium/steel transition joints are to be manufactured and tested in accordance with the appropriate requirements of Ch.1 and 2 and those detailed in this Chapter.

1.1.6 Consideration may be given to aluminium alloys not specified in this chapter and to alternative temper conditions, complying with recognized national or international standards with specifications equivalent to the requirements of this chapter.

## Section 2

## Wrought Aluminium Alloys

### 2.1 Scope

2.1.1 This Section deals with wrought aluminium alloys for structural applications including plates, sections, tubes, bars and rivet bars and rivets.

2.1.2 Wrought aluminium alloys are to have a satisfactory resistance to corrosion in marine environment. Grades for welded structures are to be weldable, applying one of the welding methods approved by Designated Authority/Classification Society.

2.1.3 The alloy grades 6005A, 6061 of the 6000 series should not be used in direct contact with sea water unless protected by anodes and/or paint system.

### 2.2 Manufacture

2.2.1 Aluminium alloys are to be manufactured at Works approved by Designated Authority/Classification Society. Also refer Chapter 1, Section 1, Cl. 1.3.2.

2.2.2 The alloys may be cast either in ingot moulds or by an approved continuous casting process. Plates are to be formed by rolling and may be hot or cold finished. Bars and sections may be formed by rolling, extrusion or drawing.

### 2.3 Quality of materials

2.3.1 Materials are to be free from surface or internal defects of such a nature as would be harmful in service.

### 2.4 Dimensional tolerances

2.4.1 The dimensional tolerances are to be in accordance with Table 2.4.1, Table 2.4.2 and Table 2.4.3 and are minimum requirements.

2.4.2 Dimensional tolerances other than those given in Table 2.4.1, Table 2.4.2 and Table 2.4.3 are to comply with a recognized national or international standard.

### 2.5 Chemical composition

2.5.1 Samples for chemical analysis are to be taken representative of each cast, or the equivalent where a continuous melting process is involved.

2.5.2 The chemical composition of these samples is to comply with the requirements of Table 2.5.1.

**Table 2.4.1 : Under thicknesses tolerances for rolled products**

| | **Thickness tolerances for nominal width [mm]** | | |
|---|---|---|---|
| Nominal thickness [t] [mm] | $w \le 1500$ | $1500 < w \le 2000$ | $2000 < w \le 3500$ |
| $3.0 \le t < 4.0$ | 0.10 | 0.15 | 0.15 |
| $4.0 \le t < 8.0$ | 0.20 | 0.20 | 0.25 |
| $8.0 \le t < 12.0$ | 0.25 | 0.25 | 0.25 |
| $12.0 \le t < 20.0$ | 0.35 | 0.40 | 0.50 |
| $20.0 \le t < 50.0$ | 0.45 | 0.50 | 0.65 |

**Table 2.4.2 : Under thicknesses tolerances for extruded open profiles**

| | Thickness tolerances for nominal thicknesses for a diameter of the circumscribing circle [mm] | | |
|---|---|---|---|
| Nominal thickness [mm] | Upto 250 | From 250 to 400 | Above 400 |
| From 3 to 6 | 0.25 | 0.35 | 0.40 |
| From 6 to 50 | 0.30 | 0.40 | 0.45 |

**Table 2.4.3 : Under thicknesses tolerances for extruded closed profiles**

| Nominal thickness [mm] | Thickness tolerances [mm] |
|---|---|
| From 3 to 6 | 0.25 |
| From 6 to 50 | 0.30 |

| Table 2.5.1 : Chemical composition | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Grade | Al | Si | Fe | Cu | Mn | Mg | Cr | Zn | Ti | Oth-ers (2) | Oth-ers (2) | Misc. |
| | % | % | % | % | % | % | % | % | % | Each % | Total % | |
| 5059 | Remainder | 0.45 | 0.50 | 0.25 | 0.6-1.2 | 5.0-6.0 | 0.25 | 0.40-0.90 | 0.20 | 0.05 3) | 0.15 4) | |
| 5083 | Remainder | ≤ 0.40 | ≤ 0.40 | ≤ 0.10 | 0.4-1.0 | 4.0-4.9 | 0.05-0.25 | ≤ 0.25 | ≤ 0.15 | ≤ 0.05 | ≤ 0.15 | |
| 5086 | Remainder | ≤ 0.40 | ≤ 0.50 | ≤ 0.10 | 0.20-0.7 | 3.5-4.5 | 0.05-0.25 | ≤ 0.25 | ≤ 0.15 | ≤ 0.05 | ≤ 0.15 | |
| 5383 | Remainder | 0.25 | 0.25 | 0.20 | 0.7-1.0 | 4.0-5.2 | 0.25 | 0.40 | 0.15 | 0.05 3) | 0.15 3) | |
| 5754 | Remainder | ≤ 0.40 | ≤ 0.40 | ≤ 0.10 | ≤ 0.50 | 2.6-3.6 | ≤ 0.30 | ≤ 0.20 | ≤ 0.15 | ≤ 0.05 | ≤ 0.15 | 0.10 ≤ Mn + Cr ≤ 0.60 |
| 5456 | Remainder | 0.25 | 0.40 | 0.10 | 0.50 – 1.0 | 4.7 – 5.5 | 0.05 – 0.20 | 0.25 | 0.20 | 0.05 | 0.15 | |
| 6005-A | Remainder | 0.50-0.9 | ≤ 0.35 | ≤ 0.30 | ≤ 0.50 | 0.040-0.7 | ≤ 0.30 | ≤ 0.20 | ≤ 0.10 | ≤ 0.05 | ≤ 0.15 | 0.12 ≤ Mn + Cr ≤ 0.50 |
| 6061 | Remainder | 0.40-0.8 | ≤ 0.7 | 0.15-0.40 | ≤ 0.15 | 0.8-1.2 | 0.04-0.35 | ≤ 0.25 | ≤ 0.15 | ≤ 0.05 | ≤ 0.15 | |
| 6082 | Remainder | 0.7-1.3 | ≤ 0.50 | ≤ 0.10 | 0.40-1.0 | 0.6-1.2 | ≤ 0.25 | ≤ 0.20 | ≤ 0.10 | ≤ 0.05 | ≤ 0.15 | |

**Notes:**

1. Slight variations in the content of some elements, compared with values indicated in this Table may be accepted with Designated Authority/Classification Society 's agreement.
2. Other metallic elements such as Ni, Ga.V are considered as impurities. The regular analysis need not be made for these elements.
3. Zr: maximum 0.20. The total for other elements does not include Zirconium.
4. Zr: 0.05-0.25. The total for other elements does not include Zirconium.

2.5.3 The manufacturer’s declared analysis will be accepted subject to occasional checks if required by Designated Authority/Classification Society Surveyor, particularly, product analysis may be required where the final product chemistry is not well represented by the analysis from the cast.

2.5.4 When the aluminium alloys are not cast in the same works in which they are manufactured into semi finished products, the works is to give a certificate detailing the chemical composition and heat number.

**2.6 Heat treatment**

2.6.1 Temper conditions (delivery heat treatment) are defined in Table 2.8.1.

**2.7 Test material**

2.7.1 All materials in a lot forwarded for sampling are to be of the same alloy, production batch and product form (plates, sections etc.). The materials in one lot are to be of the same dimensions and in the same delivery condition. Artificially aged grades are to be from the same furnace batch.

2.7.2 Wherever practicable, the tensile test pieces for rolled and extruded sections are to be of full section of material. Otherwise, the pieces are to be taken in the range one third to half the distance from the edge to center of the predominant or thickest part of the section.

**2.8 Testing and inspection**

2.8.1 Testing procedures

The test specimens and procedures are to be in accordance with Ch.2.

2.8.2 Verification of proper fusion of press welds for closed profiles.

The Manufacturer has to demonstrate by macrosection tests or drift expansion tests of closed

profiles performed on each batch of closed profiles that there is no lack of fusion at the press welds.

2.8.3 Drift expansion tests

2.8.3.1 Every fifth profile is to be sampled after final heat treatment.

One sample is to be selected from the batches of five profiles or less.

Every profile is to be selected if the length exceeds 6 [m].

2.8.3.2 Two samples are to be cut from the front and back end of each production profile.

2.8.3.3 The test specimens are to be cut with the ends perpendicular to the axis of the profile. The edges of the end may be rounded by filing.

2.8.3.4 The length of the specimen is to be in accordance with details given in Chapter 2.

2.8.3.5 Testing is to be carried out at ambient temperature and is to consist of expanding the end of the profile by means of a hardened conical steel mandrel having an included angle of at least 60°.

2.8.3.6 The sample is considered to be unacceptable if the sample fails with a clean split along the weld line which confirms lack of fusion.

2.8.4 Requirements of mechanical properties for rolled products in different delivery conditions are given in Table 2.8.1 and are applicable for thickness within the range 3 [mm] to 50 [mm]. For thickness above 10 [mm], however, lower mechanical properties may be accepted.

2.8.5 Requirements of mechanical properties for extruded products in different delivery conditions are given in Table 2.8.2 and are applicable for thickness within the range 3 [mm] to 50 [mm].

2.8.6 Requirements of mechanical properties and delivery conditions for extruded closed profiles are given in Table 2.8.3.

2.8.7 Other delivery conditions with related mechanical properties may be accepted by Designated Authority/Classification Society, in each particular case.

**Table 2.8.1 : Mechanical properties for rolled products 3 [mm] ≤ t ≤ 50 [mm]**

| Grade | Temper [3] condition | Thickness, [t] | 0.2% proof stress [N/mm$^2$] | Tensile strength [N/mm$^2$] | Elongation % minimum [1] | |
|---|---|---|---|---|---|---|
| | | | | | On gauge length of 50 [mm] | On gauge length of 5 x dia |
| 5083 | O | $3 \le t \le 50$ mm | 125 | 275-350 | 16 | 14 |
| | H111 | $3 \le t \le 50$ mm | 125 | 275-350 | 16 | 14 |
| | H112 | $3 \le t \le 50$ mm | 125 | 275 | 12 | 10 |
| | H116 | $3 \le t \le 50$ mm | 215 | 305 | 10 | 10 |
| | H321 | $3 \le t \le 50$ mm | 215-295 | 305-385 | 12 | 10 |
| 5383 | O | $3 \le t \le 50$ mm | 145 | 290 | - | 17 |
| | H111 | $3 \le t \le 50$ mm | 145 | 290 | - | 17 |
| | H116 | $3 \le t \le 50$ mm | 220 | 305 | 10 | 10 |
| | H321 | $3 \le t \le 50$ mm | 220 | 305 | 10 | 10 |
| 5059 | O | $3 \le t \le 50$ mm | 160 | 330 | 24 | 24 |
| | H111 | $3 \le t \le 50$ mm | 160 | 330 | 24 | 24 |
| | H116 | $3 \le t \le 20$ mm | 270 | 370 | 10 | 10 |
| | | $20 < t \le 50$ mm | 260 | 360 | - | 10 |
| | H321 | $3 \le t \le 20$ mm | 270 | 370 | 10 | 10 |
| | | $20 < t \le 50$ mm | 260 | 360 | - | 10 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 5086 | O | 3 ≤ t ≤ 50 mm | 95 | 240-305 | 16 | 14 |
| | H111 | 3 ≤ t ≤ 50 mm | 95 | 240-305 | 16 | 14 |
| | H112 | 3 ≤ t ≤ 12.5 mm | 125 | 250 | 8 | |
| | | 12.5 < t ≤ 50 mm | 105 | 240 | | 9 |
| | H116 | 3 ≤ t ≤ 50 mm | 195 | 275 | 10 [2)] | 9 |
| 5754 | O | 3 ≤ t ≤ 50 mm | 80 | 190-240 | 18 | 17 |
| | H111 | 3 ≤ t ≤ 50 mm | 80 | 190-240 | 18 | 17 |

**Table 2.8.1 : (Contd.)**

| Grade | Temper [3)] condition | Thickness, t | 0.2% proof stress [N/mm$^2$] | Tensile strength [N/mm$^2$] | Elongation % minimum [1)] | |
|---|---|---|---|---|---|---|
| | | | | | On gauge length of 50 [mm] | On gauge length of 5 x dia |
| 5456 | O | 3 ≤ t ≤ 6.3 mm | 130-205 | 290-365 | 16 | |
| | | 6.3 < t ≤ 50 mm | 125-205 | 285-360 | 16 | 14 |
| | H116 | 3 ≤ t ≤ 30 mm | 230 | 315 | 10 | 10 |
| | | 30 < t ≤ 40 mm | 215 | 305 | | 10 |
| | | 40 < t ≤ 50 mm | 200 | 285 | | 10 |
| | H321 | 3 ≤ t ≤ 12.5 mm | 230-315 | 315-405 | 12 | |
| | | 12.5 < t ≤ 40 mm | 215-305 | 305-385 | | 10 |
| | | 40 < t ≤ 50 mm | 200-295 | 285-370 | | 10 |

Notes:

1) Elongation in 50 mm apply for thicknesses upto and including 12.5 mm and in 5d for thicknesses over 12.5 mm.
2) 8% for thicknesses upto and including 6.3 mm.
3) The mechanical properties for the O and H111 tempers are the same. However, they are separated to discourage dual certification as these tempers represent different processing.

| Designation | Condition |
|---|---|
| F | As fabricated |
| O | Annealed, soft |
| H1 | Strain hardened only |
| H2 | Strain hardened and partially annealed |
| H3 | Strain hardened and thermally stabilized |
| H321 | Strain hardened and stabilized |
| H11 | Strain hardened to specified strength |
| H12 | Strain hardened to specified strength |
| H13 | Strain hardened to specified strength |

| | |
|---|---|
| H111 | Less strain hardened than H11 e.g. by straightening or stretching |
| H112 | No controlled strain hardening, but there are mechanical property limits |
| H116 | Treatment against exfoliation corrosion |
| T5 | Cooled from an elevated temperature shaping process and then artificially aged |
| T6 | Solution heat treated and then artificially aged. |

**Table 2.8.2 : Mechanical properties for extruded products 3 [mm] ≤ t ≤ 50 mm**

| Grade | Temper condition | Thickness, t | 0.2% proof stress [N/mm$^2$] | Tensile strength [N/mm$^2$] | Elongation % minimum 1) | |
|---|---|---|---|---|---|---|
| | | | | | On gauge length of 50 [mm] | On gauge length of 5 x dia |
| 5083 | O | 3 ≤ t ≤ 50 mm | 110 | 270-350 | 14 | 12 |
| | H/111 | 3 ≤ t ≤ 50 mm | 165 | 275 | 12 | 10 |
| | H112 | 3 ≤ t ≤ 50 mm | 110 | 270 | 12 | 10 |
| 5383 | O | 3 ≤ t ≤ 50 mm | 145 | 290 | 17 | 17 |
| | H111 | 3 ≤ t ≤ 50 mm | 145 | 290 | 17 | 17 |
| | H112 | 3 ≤ t ≤ 50 mm | 190 | 310 | | 13 |
| 5059 | H112 | 3 ≤ t ≤ 50 mm | 200 | 330 | | 10 |
| 5086 | O | 3 ≤ t ≤ 50 mm | 95 | 240-315 | 14 | 12 |
| | H111 | 3 ≤ t ≤ 50 mm | 145 | 250 | 12 | 10 |
| | H112 | 3 ≤ t ≤ 50 mm | 95 | 240 | 12 | 10 |
| 6005A | T5 | 3 ≤ t ≤ 50 mm | 215 | 260 | 9 | 8 |
| | T6 | 3 ≤ t ≤ 10 mm | 215 | 260 | 8 | 6 |
| | | 10 ≤ t ≤ 50 mm | 200 | 250 | 8 | 6 |
| 6061 | T6 | 3 ≤ t ≤ 50 mm | 240 | 260 | 10 | 8 |
| 6082 | T5 | 3 ≤ t ≤ 50 mm | 230 | 270 | 8 | 6 |
| | T6 | 3 ≤ t ≤ 50 mm | 250 | 290 | 6 | |
| | | 3 ≤ t ≤ 50 mm | 260 | 310 | 10 | 8 |

Notes:

1) The values are applicable for longitudinal and transverse tensile test specimens as well.

2) Elongation in 50 mm applies for thicknesses upto and including 12.5 mm and in 5d for thicknesses over 12.5 mm.

**Table 2.8.3 : Mechanical properties for extruded closed profiles (testing transverse to extruding direction)**

| Grade | Temper condition | 0.2% proof stress [N/mm$^2$] | Tensile strength [N/mm$^2$] | Elongation % min on gauge length of 5 x dia |
|---|---|---|---|---|
| 6061 | T5/T6 | 205 | 245 | 4 |
| 6005A | T5/T6 | 215 | 250 | 5 |
| 6082 | T5/T6 | 240 | 290 | 5 |

**2.9 Freedom from defects**

2.9.1 The finished material is to have a good finish and is to be free from internal and surface defects prejudicial to the use of the concerned material for the intended application.

2.9.2 Slight surface imperfections may be removed by smooth grinding or machining as long as the thickness of the material remains within the tolerances given in 2.4.

**2.10 Corrosion testing**

2.10.1 Rolled 5xxx-alloys of type 5083, 5383, 5059, 5086 and 5456 in the H116 and H321 tempers intended for use in marine hull construction or in marine applications where frequent direct contact with seawater is expected, are to be corrosion tested with respect to exfoliation and intergranular corrosion resistance.

2.10.2 The manufacturers are to establish the relationship between microstructure and resistance to corrosion when the above alloys are approved. A reference photomicrograph taken at 500x under the conditions specified in ASTM B928:2015, Section 9.4.1, is to be established for each of the alloy-tempers and relevant thickness ranges. The reference photographs are to be taken from samples which have exhibited no evidence of exfoliation corrosion and a pitting rating of PB or better, when subjected to the test described in ASTM G66:2018 "Standard test method for visual assessment of exfoliation, corrosion susceptability of 5xxx series aluminium alloys" (ASSET Test). The samples are also to have exhibited resistance to intergranular corrosion at a mass loss not greater than 15 [mg/cm$^2$], when subjected to tests described in ASTM G67:2018 "Standard test method for determining the susceptibility to intergranular corrosion of 5xxx series aluminium alloys by mass loss after exposure to nitric acid" (NAMLT). Upon satisfactory establishment of the relationship between microstructure and resistance to corrosion, the master photomicrographs and the results of the corrosion tests are to be approved by Designated Authority/Classification Society. Production practices are not to be changed after approval of the reference micrographs.

Other test methods may also be accepted at the discretion of Designated Authority/Classification Society.

2.10.3 For batch acceptance of 5xxx-alloys in the H116 and H321 tempers, metallographic examination of one sample selected from mid width at one end of a coil or random sheet or plate is to be carried out. The microstructure of the sample is to be compared to the reference photomicrograph of acceptable material in the presence of the Surveyor. A longitudinal section perpendicular to the rolled surface is to be prepared for metallographic examination under the conditions specified in ASTM B928:2015, Section 9.6.1. If the microstructure shows evidence of continuous grain boundary network of aluminium-magnesium precipitate in excess of the reference photomicrographs of acceptable material, the batch is either to be rejected or tested for exfoliation-corrosion resistance and intergranular corrosion resistance subject to the agreement of the Surveyor. The corrosion tests are to be in accordance with ASTM G66:2018 and G67:2018 or equivalent standards. Acceptance criteria are as noted below:

i) The sample is to exhibit no evidence of exfoliation corrosion

ii) The pitting rating of the sample is to be PB or better when subjected to ASTM G66:2018 ASSET test

iii) The sample is to exhibit resistance to intergranular corrosion at a mass loss no greater than 15 [mg/cm$^2$] when subjected to ASTM G67:2018 NAMLT test.

If the results from testing satisfy the acceptance criteria the batch is accepted, else it is to be rejected.

As an alternative to metallographic examination, each batch may be tested for exfoliation-corrosion resistance and intergranular corrosion resistance, in accordance with ASTM G66:2018 and G67:2018 under the conditions specified in ASTM B928:2015 or equivalent standards. If this alternative is used, then the results of the test must satisfy the acceptance criteria stated above.

**2.11 Test materials**

2.11.1 Definition of batches

Each batch is made up of products:

- of the same alloy grade and from the same cast
- of the same product form and similar dimensions (for plates, the same thickness)
- manufactured by the same process
- having been submitted simultaneously to the same temper condition.

2.11.2 The test samples are to be taken

- at one third of the width from a longitudinal edge of rolled products.
- in the range 1/3 to 1/2 of the distance from the edge to the centre of the thickest part of extruded products.

2.11.3 Test samples are to be taken so that the orientation of test specimens is as follows:

a) Rolled products

Normally, tests in the transverse direction are required. If the width is insufficient to obtain transverse test specimen, or in the case of strain hardening alloys, tests in the longitudinal direction will be permitted.

b) Extruded products

The extruded products are tested in longitudinal direction.

2.11.4 After removal of test samples, each test specimen is to be marked in order that its original identity, location and orientation is maintained.

**2.12 Mechanical test specimens**

2.12.1 Type and location of tensile test specimens are to be in accordance with details given in Ch.2.

**2.13 Number of test specimens**

2.13.1 Tensile test

a) Rolled products

- One tensile test specimen is to be taken from each batch of the product. If the weight of one batch exceeds 2000 [kg], one extra tensile test specimen is to be taken from every 2000 [kg] of the product or fraction thereof, in each batch.
- For single plates or for coils weighing more than 2000 [kg] each, only one tensile test specimen per plate or coil shall be taken.

b) Extruded products

- For the products with a nominal weight of less than 1 [kg/m], one tensile test specimen is to be taken from each 1000 [kg], or fraction thereof, in each batch. For nominal weights between 1 and 5 [kg/m], one tensile test specimen is to be taken from each 2000 [kg] or fraction hereof, in each batch. If the nominal weight exceeds 5 [kg/m], one tensile test specimen is to be taken for each 3000 [kg] of the product or fraction thereof, in each batch.

2.13.2 Corrosion tests

For rolled plates of grade 5083, 5383, 5059 and 5086 delivered in the tempers H116 or H321, one sample is to be tested per batch.

**2.14 Retest procedures**

2.14.1 When the tensile test from the first piece selected in accordance with Sec.11 fails to meet the requirements, two further tensile tests may be made from the same piece. If both of these additional tests are satisfactory, this piece and the remaining pieces from the same batch may be accepted.

2.14.2 If one or both the additional tests referred to above are unsatisfactory, the piece is to be rejected, but the remaining material from the same batch may be accepted provided that two of the remaining pieces in the batch selected in the same way, are tested with satisfactory results. If unsatisfactory results are obtained from either of these two pieces then the batch of material is to be rejected.

2.14.3 In the event of any material bearing the Designated Authority/Classification Society brand failing to comply with the test requirements, the brand mark is to be unmistakably defaced by the manufacturer.

**2.15 Visual and non-destructive examination**

2.15.1 Surface inspection and verification of dimensions are the responsibility of the manufacturer, and acceptance by the Surveyors of material later found to be defective shall not absolve the manufacturer from this responsibility.

2.15.2 In general, the non-destructive examination of materials is not required for acceptance purposes. Manufacturers are expected, however to employ suitable methods of non-destructive examination for the general maintenance of quality standards.

2.15.3 For applications where the non-destructive examination of materials is considered to be necessary, the extent of this examination, together with appropriate acceptance standards, are to be agreed between the purchaser, manufacturer and Surveyor.

**2.16 Rectification of defects**

2.16.1 Local surface defects may be removed by machining or grinding, provided the thickness of the material remains within the tolerances given in para 2.4. The extent of repairs is to be agreed upon with the Surveyor, and all repairs are to be carried out

under Surveyor's supervision, unless otherwise arranged.

2.16.2 Surface defects which cannot be dealt with as in 2.12.1 are not allowed to be repaired, unless it can be ensured that repair by welding does not affect the strength and stability of the piece for the intended purpose. Any case of repair by welding is to be specified in detail for consideration and approval by the Surveyor. Prior to any such repair welding, the defect is to be removed by machining or grinding. After complete removal of the defect and before welding the thickness of the piece at no place is to be reduced by more than 20 per cent. The welding is to be carried out by approved welders. The weld is to be ground flush with the surrounding piece surface. Before repair welding is commenced and after grinding the weld bead, suitable non destructive testing may be required at the discretion of the Surveyor.

**2.17 Identification**

2.17.1 The manufacturer is to adopt a system of identification which will ensure that all finished material in a batch presented for test is of the same nominal chemical composition.

2.17.2 Products are to be clearly marked by the manufacturer in accordance with the requirements of Ch.1. The following details are to be shown on all materials which have been accepted:

a) Manufacturer's name or trade mark;

b) Grade of alloy;

c) Identification mark which will enable the full history of the item to be traced;

d) Abbreviated designation of temper condition in accordance with para 2.6;

e) Personal stamp of the Surveyor responsible for the final inspection and also Designated Authority/Classification Society’s stamp.

f) Tempered grades that are corrosion tested in accordance with 2.12 are to be marked “M” after the temper condition, e.g. 5083 H321 M.

2.17.3 When extruded products are bundled together or packed in crates for delivery, the marking specified in para 2.17.2 are to be affixed by a securely fastened tag or label.

**2.18 Certification**

2.18.1 Each test certificate or shipping statement is to include the following particulars :

a) Purchaser's name and order number;

b) Contract number;

c) Address to which material is to be dispatched;

d) Description and dimensions;

e) Specification or grade of alloys;

f) Identification mark which will enable the full history of the item to be traced;

g) Chemical composition;

h) Mechanical test results (Not required on shipping statement);

i) Details of heat treatment, where applicable; and

j) Corrosion test results (if any).

2.18.2 Where the alloy is not produced at the works at which it is wrought, a certificate is to be supplied by the Manufacturer of the alloy stating the cast number and chemical composition. The works at which alloys are produced must be approved by Designated Authority/Classification Society. Also refer Chapter 1, Section 1, Cl. 1.3.2.

## Section 3

## Aluminium Alloy Castings

**3.1 Scope**

3.1.1 Provision is made in this section for aluminium alloy castings intended for use in the construction of ships, ships for liquid chemicals and other marine structures, liquefied gas piping systems where the design temperature is not lower than minus 165°C. These materials should not be used for piping outside cargo tanks except for short lengths of pipes attached to cargo tanks in which case fire resisting insulation should be provided.

3.1.2 Castings are to be manufactured and tested in accordance with Ch.1 and Ch.2 and also with the requirements of this Section.

3.1.3 As an alternative to 3.1.2, castings which comply with National/International and proprietary specifications may be accepted provided that these specifications give reasonable equivalence to the requirements of this Section or are approved for a specific application. Generally survey and certification are to be carried out in accordance with the requirements of Ch.1.

**3.2 Manufacture**

3.2.1 Castings are to be manufactured at foundries approved by Designated Authority/Classification Society.

**3.3 Quality of castings**

3.3.1 All castings are to be free from surface or internal defects which would be prejudicial to their proper application in service.

**3.4 Chemical composition**

3.4.1 The chemical composition of a sample from each cast is to comply with the requirements given in Table 3.4.1. Suitable grain refining elements may be used at the discretion of the Manufacturer. The content of such elements is to be reported in ladle analysis.

3.4.2 Where it is proposed to use alloys not specified in Table 3.4.1 details of chemical composition, heat treatment and mechanical properties are to be submitted for approval.

3.4.3 When a cast is wholly prepared from ingots for which an analysis is already available, and provided that no significant alloy additions are made during melting, the ingot maker's certified analysis can be accepted subject to occasional checks as required by the Surveyor.

**Table 3.4.1 : Chemical composition for aluminium alloy castings**

| Alloy Element % | Grade | | | |
|---|---|---|---|---|
| | AlMg3 | AlSi12 | AlSi10Mg | AlSi7 High purity |
| Copper | 0.1 max | 0.1 max. | 0.1 max. | 0.1 max. |
| Magnesium | 2.5 - 4.5 | 0.1 max. | 0.15 - 0.4 | 0.25 - 0.45 |
| Silicon | | 0.5 max. 11.0 - 13.5 | 9.0 - 11.0 | 6.5 - 7.5 |
| Iron | 0.5 max. | 0.7 max. | 0.6 max. | 0.2 max. |
| Manganese | 0.6 max. | 0.5 max. | 0.6 max. | 0.1 max. |
| Zinc | 0.2 max. | 0.1 max. | 0.1 max. | 0.1 max. |
| Chromium | 0.1 max. | - | - | - |
| Titanium | 0.2 max. | 0.2 max. | 0.2 max. | 0.2 max. |
| Others | | | | |
| each | 0.05 max. | 0.05 max. | 0.05 max. | 0.05 max. |
| Total | 0.15 max. | 0.15 max. | 0.15 max. | 0.15 max. |
| Aluminium | Remainder | Remainder | Remainder | Remainder |

**3.5 Heat treatment**

3.5.1 Castings are to be supplied in the following conditions:

| | |
|---|---|
| Grade Al-Mg 3 | As manufactured |
| Grade Al-Si 12 | As manufactured |
| Grade Al-Si 10 Mg | As manufactured or solution heat treated and precipitation hardened |
| Grade Al-Si 7 Mg | Solution heat treated and precipitation (high purity) hardened |

**3.6 Mechanical tests**

3.6.1 At least one tensile specimen is to be tested from each cast, where heat treatment is involved, for each treatment batch from each cast. Where continuous melting is employed 500 [kgs] of fettled castings may be regarded as a cast.

3.6.2 The test samples are to be separately cast in moulds made from the same type of material as used for the castings. These moulds should conform to National Standards.

3.6.3 The methods and procedures for the identification of the test specimens, and the castings they represent, are to be agreed with the Surveyor. The identification marks are to be maintained during the preparation of test specimens.

3.6.4 Where castings are supplied in the heat treated condition, the test samples are to be heat treated together with the castings which they represent prior to testing.

3.6.5 The results of all tensile tests are to comply with the appropriate requirements given in Table 3.6.1 and/or Table 3.6.2.

| Table 3.6.1 : Minimum mechanical properties for acceptance purpose of sand cast and investment cast reference test pieces | | | |
|---|---|---|---|
| **Alloy** | **Temper (see Note)** | **Tensile strength [N/mm$^2$]** | **Elongation %** |
| AlMg3 | M | 150 | 5 |
| AlSi12 | M | 150 | 3 |
| AlSi10Mg | M | 150 | 2 |
| AlSi10Mg | TF | 220 | 1 |
| AlSi7Mg | TF | 230 | 5 |
| Note<br>M - As cast condition<br>TF - Solution heat treated and precipitation hardened condition | | | |

| Table 3.6.2 : Minimum mechanical properties for acceptance purpose of chill cast reference test pieces | | | |
|---|---|---|---|
| **Alloy** | **Temper (see Note)** | **Tensile strength [N/mm$^2$]** | **Elongation %** |
| AlMg3 | M | 150 | 5 |
| AlSi12 | M | 170 | 3 |
| AlSi10Mg | M | 170 | 3 |
| AlSi10Mg | TF | 240 | 1.5 |
| AlSi7Mg | TF | 250 | 5 |
| Note<br>M - As cast condition<br>TF - Solution heat treated and precipitation hardened condition | | | |

**3.7 Visual examination**

3.7.1 All castings are to be cleaned and adequately prepared for inspection.

3.7.2 The accuracy and verification of dimensions are the responsibility of the manufacturer, unless otherwise agreed.

3.7.3 Before acceptance, all castings are to be presented to the Surveyor for visual examination.

**3.8 Rectification of defective castings**

3.8.1 At the discretion of the Surveyor, small surface blemishes may be removed by local grinding.

3.8.2 Where appropriate, repair by welding may be accepted at the discretion of the Surveyor. Such repair is to be made in accordance with an approved procedure.

**3.9 Pressure testing**

3.9.1 Where required by the relevant construction rules, castings are to be pressure tested before final acceptance. Unless otherwise agreed, these tests are to be carried out in the presence and to the satisfaction of the Surveyor.

**3.10 Identification**

3.10.1 The manufacturer is to adopt a system of identification which will enable all finished castings to be traced to the original cast and the Surveyor is to be given full facilities for tracing the casting when required.

3.10.2 All castings which have been tested and inspected with satisfactory results are to be clearly marked with following details :

a) Identification number, cast number or other numbers which will enable the full history of the casting to be traced;

b) the abbreviated name of local office of Designated Authority/Classification Society;

c) Personal stamp of the surveyor responsible for the inspection;

d) Test pressure where applicable; and

e) Date of final inspection.

3.10.3 Where small castings are manufactured in large numbers, modified arrangements for identification may be specially agreed with the Surveyor.

**3.11 Certification**

3.11.1 The manufacturer is to provide the Surveyor with a written statement giving the following particulars for each casting or batch of castings which have been accepted :

a) Purchaser name and order number;

b) Description of castings and alloy type;

c) Identification number;

d) Ingot or Cast analysis;

e) General details of heat treatment where applicable;

f) Results of mechanical tests; and

g) Test pressure, where applicable.

## Section 4

## Aluminium/Steel Transition Joints

**4.1 Scope**

4.1.1 Provision is made in this section for explosion bonded composite aluminium/steel transition joints used for connecting aluminium structures to steel plating.

4.1.2 Each design is to be separately approved by Designated Authority/Classification Society.

**4.2 Manufacture**

4.2.1 Transition joints are to be manufactured by an approved producer in accordance with an approved specification which is to include the maximum temperature allowable at the interface during welding.

4.2.2 The aluminium material is to comply with the requirements of Sec.1 and the steel is to be of an appropriate grade complying with the requirements of Ch.3.

4.2.3 Alternative materials which comply with International, National or proprietary specifications may be accepted provided that they give reasonable equivalence to the requirements of 4.2.2 or are approved for a specific application.

4.2.4 Intermediate layers between aluminium and steel may be used, in which case the material of any such layer is to be specified by the manufacturer and will be recorded in the approval certificate. Any such intermediate layer is then to be used in all production joints.

**4.3 Visual and non-destructive examination**

4.3.1 Each composite plate is to be subjected to 100 per cent visual and ultrasonic examination in accordance with a relevant National/ International standard to determine the extent of any unbounded areas. The unbounded areas are unacceptable and any such area and the surrounding 25 [mm] area is to be discarded.

**4.4 Mechanical tests**

4.4.1 Two shear test specimens and two tensile test specimens are to be taken from each end of each composite plate for tests to be made on bond strength. One shear and one tensile test specimen from each end are to be tested at ambient temperature after heating to the maximum allowable interface temperature; the other two specimens are to be tested without heat treatment.

4.4.2 Shear tests may be made on a specimen as shown in Fig.4.4.1 or an appropriate equivalent. Tensile tests may be made across the interface by welding extension pieces to each surface or by the ram method shown in Fig.4.4.2 or by an appropriate alternative method.

4.4.3 The shear and tensile strengths of all the test specimens are to comply with the requirements of the manufacturing specification.

4.4.4 If either the shear or tensile test strength of the bond is less than the specified minimum but not less than 70 per cent of the specified minimum, two additional shear and two tensile test specimens from each end of the composite plate are to be tested and, in addition bend tests as described in 4.4.6 and Table 4.4.1 are to be conducted.

4.4.5 If either the shear or the tensile strength of the bond is less than 70 per cent of the specified minimum the case is to be investigated. After evaluation of the results of this investigation Designated Authority/Classification Society will consider the extent of composite plate which is to be rejected.

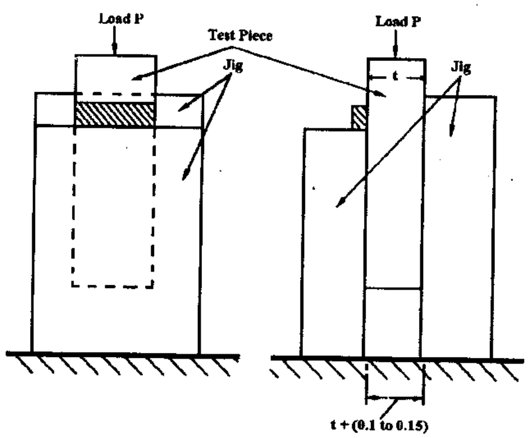



**Fig.4.4.1 : Shear tests**

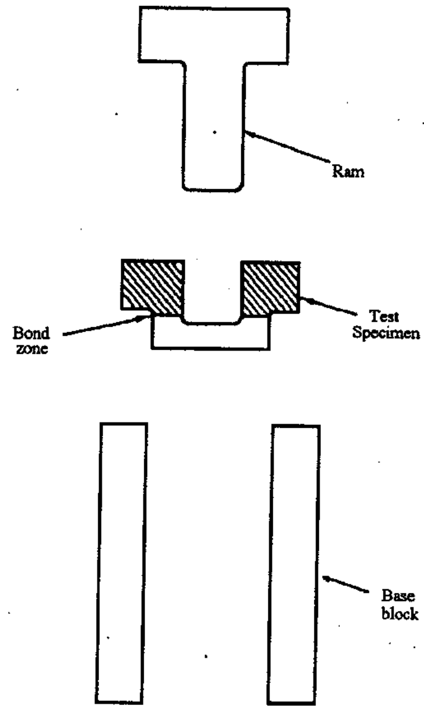



**Fig.4.4.2 : Tensile tests**

4.4.6 Bend tests, when required, are to be made under the following conditions, as listed in Table 4.4.1 :

a) the aluminium plate is in tension;

b) the steel plate is in tension; and

c) a side bend is applied.

**Table 4.4.1 : Bend tests on explosion bonded aluminium / steel transition joints**

| Type of test | Minimum bend, degrees | Diameter of former |
|---|---|---|
| Aluminium in tension | 90 | 3T |
| Steel in tension | 90 | 3T |
| Side bend | 90 | 6T |

**4.5 Identification**

4.5.1 Each acceptable transition strip is to be clearly marked with Designated Authority/Classification Society brand and the following particulars :

a) Manufacturers name or trade mark;

b) Identification mark for the grade of aluminium; and

c) Identification mark for the grade of steel.

The particulars are to be stamped on the aluminium surface at one end of the strip.

**4.6 Certification**

4.6.1 Each test certificate or shipping statement is to include the following particulars :

a) Purchaser's name and order number;

b) The contract number for which the material is intended, if known;

c) Address to which the material is dispatched;

d) Description and dimensions of the material;

e) Specification or grades of both the aluminium alloy and the steel and any intermediate layer;

f) Cast numbers of steel and aluminium plates;

g) Identification number of the composite plate; and

h) Mechanical test results (not required on the shipping statement).

# Chapter 10

# Equipment

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## Section 1

## Anchors

### 1.1 Scope

1.1.1 The following paragraphs give requirements for cast, forged or fabricated steel anchor heads, shanks and anchor shackles. The requirements given in this section are applicable to the following types of anchors:

a) Ordinary stockless and stocked anchors

b) High Holding Power (HHP) anchors, and

c) Super High Holding Power (SHHP) anchors not exceeding 1500 [kg] in mass.

### 1.2 Manufacture

1.2.1 Cast steel anchor heads, shanks and shackles are to be manufactured and tested in accordance with the relevant requirements for castings for welded construction of Ch.4. The steel is to be fine grain treated with aluminium. The toughness of steel castings for SHHP anchors is to be not less than charpy V-notch energy average of 27 J at 0°C.

1.2.2 Forged steel anchor heads, shanks, shackles and anchor crown pins are to be manufactured in accordance with the requirements for forgings of weldable quality of Ch.5.

1.2.3 Plate material and bars used for the manufacture of fabricated parts of steel anchors are to comply with the requirements of Ch.3.

For welded super high holding power (SHHP) anchors, the base steel grades are to be selected with respect to the material grade requirements for Class II in Annex 2, Chapter 2 'Materials of Construction' Section 2 'Use of Steel Grades'.

1.2.4 The welding consumables are to meet the toughness for the base steel grades in accordance with Chapter 11 'Approval of Welding Consumables for Use in Ship Construction' of this annex.

1.2.5 Fabrication is to be carried out by qualified welders using approved welding procedure.

1.2.6 The toughness of the anchor shackles for SHHP anchors is to meet that for Grade CC3 anchor chain given in Section 2. The toughness of steel castings for SHHP anchors is to be not less than charpy V-notch energy average of 27 J at 0°C.

1.2.7 Hardness values of mating parts are to be such that the more easily replaceable part wears faster.

### 1.3 Dimensions and tolerances

1.3.1 Anchors are to be manufactured as per approved drawings or as per internationally recognised designs meeting the tolerances specified in such documents. In addition the following dimensional tolerances are also to be applied:

- the clearance either side of the shank within the shackle jaws is not to be more than 3 [mm] for anchors upto 3000 [kg] mass, 4 [mm] for anchors upto 5000 [kg] mass, 6 [mm] for anchors upto 7000 [kg] mass and 12 [mm] for larger anchors.
- the shackle pin is to be push fit in the eyes of the shackle, which are to be chamfered on the

outside to ensure tightness when the pin is clenched over. The shackle pin to hole clearance is not to be more than 0.5 [mm] for pins upto 57 [mm] and not more than 1 [mm] for pins of larger diameter

- the anchor crown pin is to be snug fit within the chamber and long enough to prevent horizontal movement. The gap is not to be more than 1% of the chamber length.
- The lateral movement of the shank should not exceed 3 degrees.

**1.4 Proof test of anchors**

1.4.1 Anchors of all sizes are to be proof load tested with the load specified in Table 1.4.1. Anchors inclusive of stock, having a mass of 75 [kgs] or more (56 [kgs] in case of high holding power anchors) are to be tested at a proving establishment recognized by Designated Authority/Classification Society.

1.4.2 The proof test load is to be as given in Table 1.4.1. The mass to be used in the Table is to be as follows:-

a) For stockless anchors - the total mass of the anchor;

b) For stocked anchors - the mass of the anchor excluding the stock;

c) For high holding power anchors - a nominal mass equal to 1.33 times the actual mass of the anchor;

d) For super high holding power anchors - a nominal mass equal to 2.0 times the actual mass of the anchor.

1.4.3 The proof load is to be applied on the arm or on the palm at a spot which, measured from the extremity of the bill, is one-third of the distance between it and the centre of the crown.

In the case of the stockless anchors, both arms are to be tested at the same time, first on one side of the shank, then reversed and tested on the other.

1.4.4 Before application of proof test load the anchors are to be examined to be sure that castings are reasonably free of surface imperfections of harmful nature.

On completion of the proof load tests the anchors are to be examined for cracks and other defects and for anchors made in more than one piece, the anchors are to be examined for free rotation of their heads over the complete angle.

In every test the difference between the gauge lengths (shown in Fig.1.4.4), where one-tenth of the required load was applied first and where the load has been reduced to one-tenth of the required load from the full load, is not to exceed one percent (1%).

1.4.5 In addition to the requirements given in this Chapter attention must be given to any relevant statutory requirements of the National Authority of the country in which the ship is to be registered.

**Table 1.4.1 : Proof loads for anchors**

| Mass of anchor [kg] (1) | Proof load* [kN] (2) | Mass of anchor [kg] (1) | Proof load* [kN] (2) | Mass of anchor [kg] (1) | Proof load* [kN] (2) |
|---|---|---|---|---|---|
| 50 | 23.2 | 2000 | 349.0 | 7000 | 804.0 |
| 55 | 25.2 | 2100 | 362.0 | 7200 | 818.0 |
| 60 | 27.1 | 2200 | 376.0 | 7400 | 832.0 |
| 65 | 28.9 | 2300 | 388.0 | 7600 | 845.0 |
| 70 | 30.7 | 2400 | 401.0 | 7800 | 861.0 |
| 75 | 32.4 | 2500 | 414.0 | 8000 | 877.0 |
| 80 | 33.9 | 2600 | 427.0 | 8200 | 892.0 |
| 90 | 36.3 | 2700 | 438.0 | 8400 | 908.0 |
| 100 | 39.1 | 2800 | 450.0 | 8600 | 922.0 |
| 120 | 44.3 | 2900 | 462.0 | 8800 | 936.0 |
| 140 | 49.0 | 3000 | 474.0 | 9000 | 949.0 |
| 160 | 53.3 | 3100 | 484.0 | 9200 | 961.0 |
| 180 | 57.4 | 3200 | 495.0 | 9400 | 975.0 |
| 200 | 61.3 | 3300 | 506.0 | 9600 | 987.0 |
| 225 | 65.8 | 3400 | 517.0 | 9800 | 998.0 |
| 250 | 70.4 | 3500 | 528.0 | 10000 | 1010.0 |
| 275 | 74.9 | 3600 | 537.0 | 10500 | 1040.0 |
| 300 | 79.5 | 3700 | 547.0 | 11000 | 1070.0 |
| 325 | 84.1 | 3800 | 557.0 | 11500 | 1090.0 |

| | | | | | |
|---|---|---|---|---|---|
| 350 | 88.8 | 3900 | 567.0 | 12000 | 1110.0 |
| 375 | 93.4 | 4000 | 577.0 | 12500 | 1130.0 |
| 400 | 97.9 | 4100 | 586.0 | 13000 | 1160.0 |
| 425 | 103.0 | 4200 | 595.0 | 13500 | 1180.0 |
| 450 | 107.0 | 4300 | 604.0 | 14000 | 1210.0 |
| 475 | 112.0 | 4400 | 613.0 | 14500 | 1230.0 |
| 500 | 116.0 | 4500 | 622.0 | 15000 | 1260.0 |
| 550 | 125.0 | 4600 | 631.0 | 15500 | 1270.0 |
| 600 | 132.0 | 4700 | 638.0 | 16000 | 1300.0 |
| 650 | 140.0 | 4800 | 645.0 | 16500 | 1330.0 |
| 700 | 149.0 | 4900 | 653.0 | 17000 | 1360.0 |
| 750 | 158.0 | 5000 | 661.0 | 17500 | 1390.0 |
| 800 | 166.0 | 5100 | 669.0 | 18000 | 1410.0 |
| 850 | 175.0 | 5200 | 677.0 | 18500 | 1440.0 |
| 900 | 182.0 | 5300 | 685.0 | 19000 | 1470.0 |
| 950 | 191.0 | 5400 | 691.0 | 19500 | 1490.0 |
| 1000 | 199.0 | 5500 | 699.0 | 20000 | 1520.0 |
| 1050 | 208.0 | 5600 | 706.0 | 21000 | 1570.0 |
| 1100 | 216.0 | 5700 | 713.0 | 22000 | 1620.0 |
| 1150 | 224.0 | 5800 | 721.0 | 23000 | 1670.0 |
| 1200 | 231.0 | 5900 | 728.0 | 24000 | 1720.0 |
| 1250 | 239.0 | 6000 | 735.0 | 25000 | 1770.0 |
| 1300 | 247.0 | 6100 | 740.0 | 26000 | 1800.0 |
| 1350 | 255.0 | 6200 | 747.0 | 27000 | 1850.0 |
| 1400 | 262.0 | 6300 | 754.0 | 28000 | 1900.0 |
| 1450 | 270.0 | 6400 | 760.0 | 29000 | 1940.0 |
| 1500 | 278.0 | 6500 | 767.0 | 30000 | 1990.0 |
| 1600 | 292.0 | 6600 | 773.0 | 31000 | 2030.0 |
| 1700 | 307.0 | 6700 | 779.0 | 32000 | 2070.0 |
| 1800 | 321.0 | 6800 | 786.0 | 34000 | 2160.0 |
| 1900 | 335.0 | 6900 | 794.0 | 36000 | 2250.0 |

**Table 1.4.1 : Proof loads for anchors (Contd.)**

| **Mass of anchor [kg]** (1) | **Proof load* [kN]** (2) | **Mass of anchor [kg]** (1) | **Proof load* [kN]** (2) | **Mass of anchor [kg]** (1) | **Proof load* [kN]** (2) |
|---|---|---|---|---|---|
| 38000 | 2330.0 | 42000 | 2490.0 | 46000 | 2650.0 |
| 40000 | 2410.0 | 44000 | 2570.0 | 48000 | 2730.0 |

Proof loads for intermediate masses are to be determined by linear interpolation

Notes

Where ordinary anchors have a mass exceeding 48 000 [kg], the proof loads are to be taken as 2.059 (mass of anchor in kg)$^{2/3}$ [kN].

Where high holding power anchors have a mass exceeding 38 000 [kg], the proof loads are to be taken as 2.452 (actual mass of anchor in kg)$^{2/3}$ [kN].

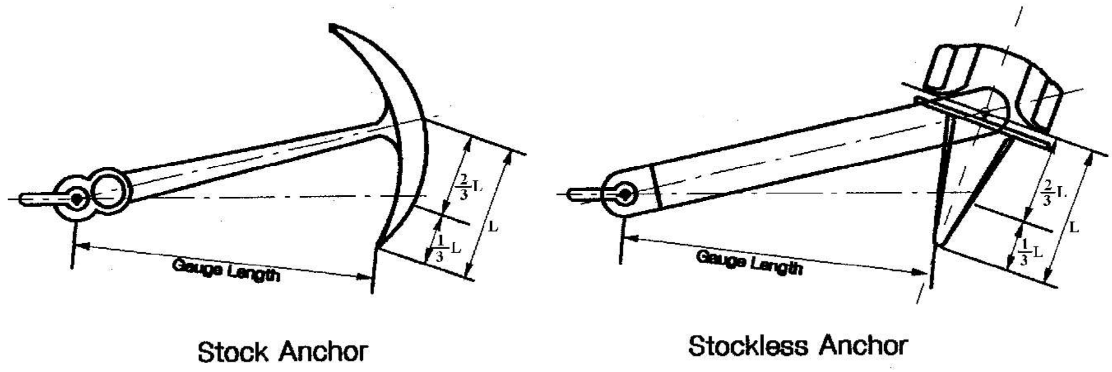



**Fig.1.4.4 : Gauge Length**

**1.5 Inspections and other tests**

1.5.1 Inspection and testing of anchor components is to be carried out as per the following:

a) Cast components are to be tested as per

Test Programme A

or

Test Programme B, where the Charpy V notch energy average of the cast material at 0°C is not less than 27J.

b) Forged / fabricated components are to be tested as per Test Programme B.

**Test Programme A** is to consist of Drop Test, Hammering Test, Visual Inspection and General NDE as described below.

**Test Programme B** is to consist of Visual Inspection, general NDE and Extended NDE as described in 1.5.5 and 1.5.6 below.

1.5.2 Drop test is to be carried out by dropping each anchor component individually from a height of 4 [m] to an iron or steel slab. The iron or steel slab should be able to resist the impact. The component under test should not fracture.

1.5.3 Hammering test is to be carried on each fluke and shank, after the drop test, by hammering the component, hung clear off the ground using a non-metallic sling, with a hammer of not less than 3 [kg] mass, to check the soundness.

1.5.4 Visual inspection is to be carried out of all accessible surfaces after the proof load test.

1.5.5 General non-destructive examination is to be carried out, after proof load testing, as per Table 1.5.5.

1.5.6 Extended non-destructive examination is to be carried out, after proof load testing, as per Table 1.5.6.

**Table 1.5.5 : General NDE for Anchors**

| **Location** | **Method of NDE** | |
|---|---|---|
| | **SHHP** | **Ordinary / HHP** |
| Feeders of castings | DP or MP and UT | DP or MP |
| Risers of castings | DP or MP and UT | DP or MP |
| All surfaces of castings | DP or MP | Not required |
| Weld repairs | DP or MP | DP or MP |
| Forged components | Not required | Not required |
| Fabrication welds | DP or MP | DP or MP |
| DP : Dye Penetrant Test | | |
| MP : Magnetic Particle Test | | |
| UT : Ultrasonic Testing | | |

| Table 1.5.6 : Extended NDE for ordinary, HHP and SHHP anchors | |
|---|---|
| **Location** | **Method of NDE** |
| Feeders of castings | DP or MP and UT |
| Risers of castings | DP or MP and UT |
| All surfaces of castings | DP or MP |
| Random areas of castings | UT |
| Weld repairs | DP or MP |
| Forged components | Not required |
| Fabrication welds | DP or MP |
| DP : Dye Penetrant Test | |
| MP : Magnetic Particle Test | |
| UT : Ultrasonic Testing | |

**1.6 Identification**

1.6.1 All identification marks are to be stamped on one side of the anchor, on the shank and the fluke, at locations reserved solely for this purpose.

1.6.2 The following details are to be marked on all the anchors:-

a) Brand mark and the abbreviated name of Designated Authority/Classification Society issuing the certificate;

b) Number of the certificate;

c) Month and year of test;

d) Mass (also the letters 'HHP/SHHP', when approved for as high holding power anchor/super high holding power anchor);

e) Mass of stock (in case of stocked anchors);

f) Personal stamp of Surveyor responsible for inspection.

g) Manufacturer's mark

h) Unique cast identification number of shank and fluke, if applicable.

1.6.3 In addition to the markings detailed in 1.6.2, each important part of the anchor is to be plainly marked with the words 'forged steel' or 'cast steel' as appropriate.

**1.7 Painting**

1.7.1 Anchors are to be painted only on completion of all inspections and tests.

**Section 2**

**Stud Link Chain Cables**

**2.1 Scope**

2.1.1 The following requirements apply to the materials, design, manufacture and testing of stud link anchor chain cables and accessories used for ships.

2.1.2 Depending upon the nominal tensile strength of the chain cable steel used for manufacture, stud link chain cables are subdivided in to three grades, namely CC1, CC2 and CC3.

**2.2 Manufacture**

2.2.1 Chain cables and accessories are to be manufactured at Works approved by Designated Authority/Classification Society for the pertinent type of chain cable, size and method of manufacture. Also refer Chapter 1, Section 1, Cl. 1.3.2.

2.2.2 Chain cables are to be preferably manufactured by flash butt welding using material suitable for CC1, CC2 or CC3 grades of chain cables. Chain cables may also be manufactured by drop forging or casting.

Accessories such as shackles, swivels and swivel shackles are to be forged or cast in steel of at least grade CC2 material. The welded construction of these components will be specially considered.

2.2.3 Details of the method of manufacture and the specification of the steel are to be submitted for approval.

2.2.4 All materials used for the manufacture of chain cables and accessories are to be supplied by manufacturer's works approved by Designated Authority/Classification Society. Also refer Chapter 1, Section 1, Cl. 1.3.2. However, for Grade CC1 steel bars, approval of material manufacturer is not required.

For Grade CC3 steel bars, detailed material specifications including manufacturing procedure, deoxidation practice, specified chemical composition, heat treatment and mechanical properties are to be submitted.

**2.3 Design and tolerances**

2.3.1 The form and proportion of chain cable links and shackles are to be in accordance with ISO 1704:2008 (see Figs.2.3.1 to 2.3.6). All dimensions in the figures are shown in multiples of the nominal diameter d of the common link. The dimensions in brackets may be chosen for studless links in outboard end swivel pieces. Where designs do not comply with this and where accessories are of welded construction, plans giving full details of the design, manufacturing process and heat treatment are to be submitted for approval.

2.3.2 The following tolerances are applicable to links with the provision that the plus tolerance may be up to 5 per cent of the nominal diameter:

a)

| **Nominal diameter Measured at the Crown (see note)** | **Max. minus tolerance** |
|---|---|
| Upto 40 [mm] | 1 [mm] |
| Over 40 and upto 84 [mm] | 2 [mm] |
| Over 84 and upto 122 [mm] | 3 [mm] |
| Over 122 and upto 152 [mm] | 4 [mm] |
| Over 152 and upto 184 [mm] | 6 [mm] |
| Over 184 and upto 222 [mm] | 7.5 [mm] |

Note : Two measurements are to be taken at the same location: one in the plane of the link (see $d_p$ in Fig.2.3.7) and one perpendicular to the plane of the link. The cross sectional area at the crown is to be calculated using the average of the diameters with negative and plus tolerance

The cross sectional area at the crown must not have any negative tolerance. For diameters of 20 [mm] or greater, the plus tolerance may be upto 5 per cent of the nominal diameter. For diameters less than 20 [mm] the plus tolerance is to be agreed with Designated Authority/Classification Society at the time of approval;

Diameter measured at locations other than the crown is to have no negative tolerance. Plus tolerance may be up to 5 per cent of the nominal diameter except at the butt weld where it is to be in accordance to manufacturer's specification, which is to be agreed with Designated Authority/Classification Society. For diameters less than 20[mm], the plus tolerance is to be agreed with Designated Authority/Classification Society at the time of approval.

a) The maximum allowable tolerance on assembly measured over a length of 5 links may equal +2.5 per cent but may not be negative (measured with the chain under tension after proof load test);

b) All other dimensions are subject to a manufacturing tolerance of ± 2.5 per cent, provided that all of the final link parts fit together properly;

c) Studs must be located in the links centrally and at right angles to the sides of the link, although the studs at each end of any length may also be located off-centre to facilitate the insertion of the joining shackle. The following tolerances are regarded as being inherent in the method of manufacture and will not be objected to provided the stud fits snugly and its ends lie practically flush against the inside of the link.

| | |
|---|---|
| Maximum off-centre distance 'X' | 10 per cent of the nominal diameter d |
| Maximum deviation "α" from the 90° position | 4° |

The tolerances are to be measured in accordance with Fig.2.3.7.

2.3.3 The following tolerances are applicable to accessories :

Nominal diameter : + 5 per cent, - 0 per cent

Other diameter : ± 2.5 per cent.

**2.4 Material for welded chain cables and accessories**

2.4.1 Bar material intended for the manufacture of welded chain cables is to be in accordance with the appropriate requirements of Ch.3. Rimming steel is not acceptable for this application.

2.4.2 Bars of the same nominal diameter are to be presented for test in batches of 50 tonnes or fraction thereof from the same cast. A suitable length from one bar in each batch is to be selected for test purposes.

2.4.3 In order to evaluate the suitability of the bar material the sample selected from each batch is to be tested in a heat treatment condition equivalent to that of the finished chain cable and accessories. For this purpose only the sample need be heat treated.

2.4.4 For all grades, one tensile test is to be taken from each sample selected. Additionally one set of three Charpy V-notch impact test specimens is to be prepared and tested as required in Table 2.4.1.

2.4.5 Where the dimensions allow, the test specimens are to be taken at approximately one-third of the radius from the outer surface as shown in Fig.2.4.1. For smaller diameters the test specimens are to be taken as close as possible to these positions.

2.4.6 The cross-sectional area of the tensile test specimen is to be not less than 150 [$mm^2$]. Alternatively, the tensile test specimen may be a suitable length of bar tested in full cross-section.

2.4.7 The impact test specimens are to be notched in the radial direction as shown in Fig.2.4.1.

2.4.8 The results of all the mechanical testing are to comply with the requirements of Table 2.4.1.

2.4.9 The average value obtained from one set of three impact test specimens is to comply with the requirements given in Table 2.4.1. One individual value only may be below the specified average value provided it is not less than 70% of that value.

If the Charpy V-notch impact test requirements are not achieved, a retest of three further specimens selected from the same sample as per 1.10.2 of Chapter 1 shall be permissible. Failure to meet the requirements will result in rejection of the test unit represented unless it can be clearly attributable to improper simulated heat treatment.

If the tensile test requirements are not achieved, a retest of two further specimens selected from the same sample shall be permissible. Failure to meet the specified requirements in either of the additional tests will result in rejection of the test unit represented unless it can be clearly attributable to improper simulated heat treatment.

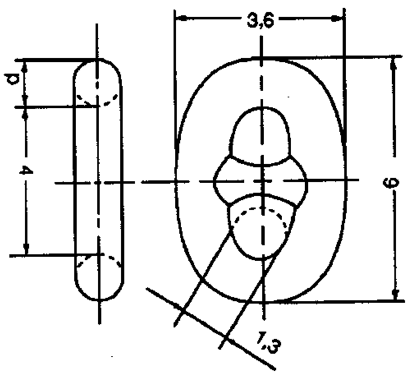



Fig. 2.3.1 : Common link

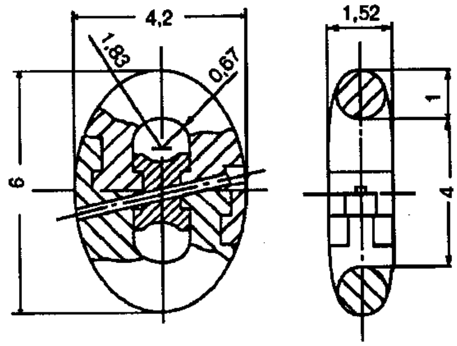



Fig. 2.3.5 : Kenter type lugless joining shackle

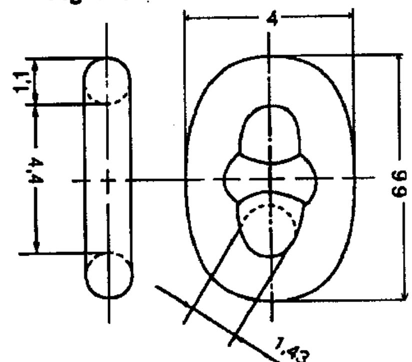



Fig. 2.3.2 : Enlarged link

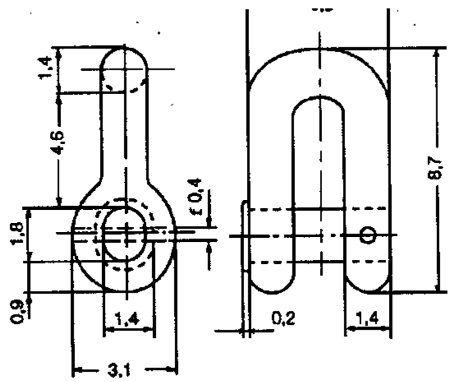



Fig. 2.3.6 : End shackle

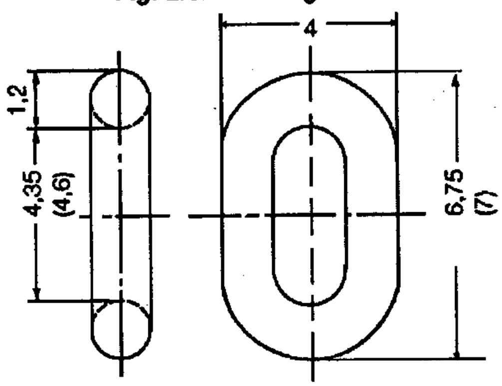



Fig. 2.3.3 : End link

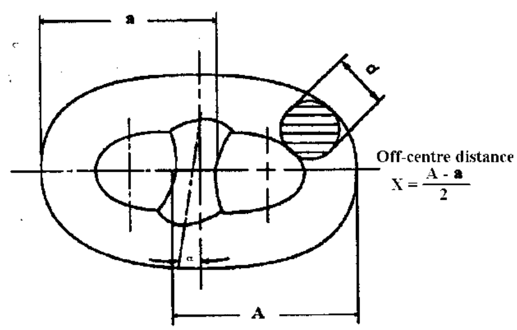



Fig. 2.3.7 : Link-stud tolerance

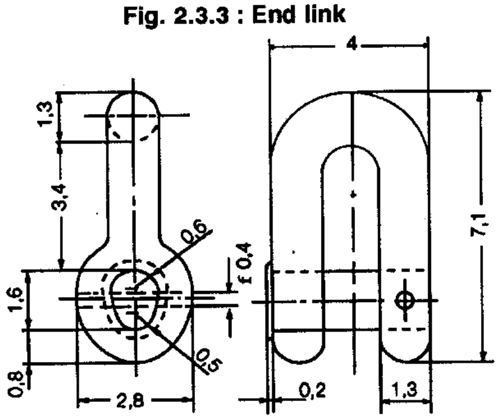



Fig. 2.3.4 : Joining shackle with shackle pin

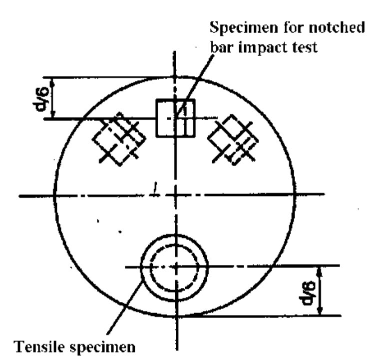



Fig. 2.4.1 : Position of test pieces

**Table 2.4.1 : Mechanical properties of rolled steel bars for acceptance purposes**

| Designation | Tensile strength $[N/mm^2]$ | Yield strength $[N/mm^2]$ min. | Elongation on 5.65 $\sqrt{S_o}$% min. | Reduction of area % min. | Impact Tests | |
|---|---|---|---|---|---|---|
| | | | | | Test temp.°C | Average energy J min.[1] |
| Grade CC1 | 370 - 490 | - | 25 | - | - | - |
| Grade CC2 | 490 - 690 | 295 | 22 | - | 0 | 27[1] |
| Grade CC3 | Min. 690 | 410 | 17 | 40 | 0[2] | 60 |
| | | | | | -20 | 35 |

1 The impact test of grade CC2 material may be waived, if the chain is to be supplied in a heat treated condition as per Table 2.9.1.

2 The impact testing is normally to be carried out at 0°C.

**Table 2.4.2 : Chemical composition of rolled steel bars**

| Designation | Chemical Composition | | | | | |
|---|---|---|---|---|---|---|
| | C max. | Si | Mn | P max. | S max. | Al (Total)[1] min. |
| Grade CC1 | 0.20 | 0.15 - 0.35 | min. 0.40 | 0.040 | 0.040 | - |
| Grade CC2[2] | 0.24 | 0.15 - 0.55 | max. 1.60 | 0.035 | 0.035 | 0.020 |
| Grade CC3[3] | To be specially considered in each case | | | | | |

1 Aluminium may be replaced partly by other grain refining elements.

2 Subject to special consideration, additional alloying elements may be added.

3 To be killed and of fine grain.

**Table 2.4.3 : Dimensional tolerance of rolled steel bars**

| Nominal diameter [mm] | Tolerance on diameter [mm] | Tolerance on roundness (dmax - dmin) [mm] |
|---|---|---|
| Less than 25 | -0 + 1.0 | 0.6 |
| 25 – 35 | -0 +1.2 | 0.8 |
| 36 – 50 | -0 + 1.6 | 1.1 |
| 51 – 80 | -0 + 2.0 | 1.5 |
| 81 – 100 | -0 +2.6 | 1.95 |
| 101 – 120 | -0 + 3.0 | 2.25 |
| 121 – 160 | -0 + 4.0 | 3.0 |
| 161 – 210 | -0 + 5.0 | 4.0 |

2.4.10 If failure to pass the tensile test or the Charpy V-notch impact test is definitely attributable to improper heat treatment of the test sample, a new test sample may be taken from the same piece and re-heat treated. The complete test (both tensile and impact test) is to be repeated and the original results obtained may be disregarded.

2.4.11 The chemical composition of the steel bars is to be generally within the limits given in Table 2.4.2.

2.4.12 The tolerances on diameter and roundness of rolled steel bars are to be within the limits specified in Table 2.4.3 unless otherwise agreed.

2.4.13 The minimum markings required for the steel bars are the manufacturers' brandmark, the steel grade and an abbreviated symbol of the heat. Steel bars having diameters of up to and including 40 mm and combined into bundles, may be marked on permanently affixed labels.

2.4.14 Material certification : Bar material for Grade 2 or Grade 3 is to be certified by Designated Authority/Classification Society. For each consignment, manufacturers shall forward to the Surveyor a certificate containing at least the following data:

- Manufacturer's name and/or purchaser's order no.
- Number and dimensions of bars and weight of consignment
- Steel specification and chain grade
- Heat number
- Manufacturing procedure
- Chemical composition
- Details of heat treatment of the test sample (where applicable)
- Results of mechanical tests (where applicable)
- Number of test specimens (where applicable).

**2.5 Material for cast chain cables and accessories**

2.5.1 Manufacture of cast steel chain cables is generally to be in accordance with Ch.4, as appropriate.

2.5.2 All castings must be properly heat treated i.e. normalized, normalized and tempered or quenched and tempered, as specified in Table 2.7.1 for the relevant grade of steel.

**2.6 Material for forged chain cables and accessories**

2.6.1 The procedure for the manufacture of drop forgings for chain cables will be specially considered, but is generally to be in accordance with the appropriate requirements of Ch.5.

2.6.2 The stock material may be supplied in the as rolled condition. Finished forgings are to be properly heat treated, i.e. normalized, normalized and tempered or quenched and tempered, as specified for the relevant grade of steel in Table 2.7.1.

**2.7 Heat treatment of completed chain cables**

2.7.1 The completed chain cable and accessories are to be heat treated in accordance with Table 2.7.1, for the appropriate grade of cable.

2.7.2 In all cases, heat treatment is to be carried out prior to the proof, load test, breaking load test and all mechanical testing.

**Table 2.7.1 : Condition of supply of chain cables and accessories**

| Grade | Chain cables | Accessories |
|---|---|---|
| **CC1** | As welded or normalized | NA |
| **CC2** | As welded or normalized 1) | Normalized |
| **CC3** | Normalized, Normalized and tempered or Quenched and tempered | Normalized, normalized and tempered or Quenched and tempered |

1) Grade CC2 chain cables made by forging or casting are to be supplied in the normalized condition

NA = Not Applicable.

**2.8 Materials and welding of studs**

2.8.1 The studs are to be made of steel corresponding to that of the chain cable or from rolled, cast or forged mild steels. The use of other materials, e.g. grey or nodular cast iron is not permitted.

2.8.2 The welding of studs is to be in accordance with an approved procedure subject to following :

a) The studs being of weldable steel;

b) The studs being welded at one end only, i.e. opposite to the weldment of the link. The stud

ends must fit inside of the link without appreciable gap;

c) The welds, preferably in the horizontal position, are to be executed by qualified welders using suitable welding consumables;

d) All the welds are to be completed before the final heat treatment of the chain cable; and

e) The welds are to be free from defects liable to impair the proper use of the chain.

**2.9 Testing of completed chain cables**

2.9.1 Finished chain cables are to be tested in the presence of a Surveyor, at a proving establishment recognized by Designated Authority/Classification Society. For this purpose the chain cables must be free from paint and anti-corrosive media. Special attention would be given to the visual inspection of the flash-butt-weld, if present. In addition to the requirements of this Chapter, attention must be given to any relevant statutory requirements of the National Authority of the country in which the ship is to be registered.

2.9.2 The design and/or standard breaking loads and proof loads of stud link chain cables are given in Table 2.9.1 (a). The test loads rounded off from the loads in 2.9.1 (a) to be used for testing and acceptance of chain cables, are given in Table 2.9.1 (b). Each length of chain is to be subjected to a proof loading test in an approved testing machine and is to withstand the load given in Table 2.9.1 for the appropriate grade and size of cable. On completion of the test, each length of cable is to be examined and is to be free from significant defects.

Should a proof load test fail, the defective link(s) is (are) to be replaced, a local heat treatment to be carried out on the new link(s) and the proof load test is to be repeated. In addition, an investigation is to be made to identify the cause of the failure.

**Table 2.9.1(a) : Formulae for proof loads and breaking loads of stud link chain cables**

| Test | Grade CC1 | Grade CC2 | Grade CC3 |
|---|---|---|---|
| Proof load (kN) | $0.00686d^2 (44 – 0.08d)$ | $0.00981d^2 (44 – 0.08d)$ | $0.01373d^2 (44 – 0.08d)$ |
| Breaking load (kN) | $0.00981d^2 (44 – 0.08d)$ | $0.01373d^2 (44 – 0.08d)$ | $0.01961d^2 (44 – 0.08d)$ |
| Note d = nominal diameter [mm] | | | |

**Table 2.9.1(b) : Test load values for stud link chain cables**

| Chain cable diameter (mm) | Grade CC1 | | Grade CC2 | | Grade CC3 | |
|---|---|---|---|---|---|---|
| | Proof load (kN) | Breaking load (kN) | Proof load (kN) | Breaking load (kN) | Proof load (kN) | Breaking load (kN) |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 11 | 36 | 51 | 51 | 72 | 72 | 102 |
| 12.5 | 46 | 66 | 66 | 92 | 92 | 132 |
| 14 | 58 | 82 | 82 | 116 | 116 | 165 |
| 16 | 76 | 107 | 107 | 150 | 150 | 216 |
| 17.5 | 89 | 127 | 127 | 179 | 179 | 256 |
| 19 | 105 | 150 | 150 | 211 | 211 | 301 |
| 20.5 | 123 | 175 | 175 | 244 | 244 | 349 |
| 22 | 140 | 200 | 200 | 280 | 280 | 401 |
| 24 | 167 | 237 | 237 | 332 | 332 | 476 |
| 26 | 194 | 278 | 278 | 389 | 389 | 556 |
| 28 | 225 | 321 | 321 | 449 | 449 | 642 |
| 30 | 257 | 368 | 368 | 514 | 514 | 735 |
| 32 | 291 | 417 | 417 | 583 | 583 | 833 |
| 34 | 328 | 468 | 468 | 655 | 655 | 937 |

| Table 2.9.1(b) : Test load values for stud link chain cables | | | | | | |
|---|---|---|---|---|---|---|
| | Grade CC1 | | Grade CC2 | | Grade CC3 | |
| Chain cable diameter (mm) | Proof load (kN) | Breaking load (kN) | Proof load (kN) | Breaking load (kN) | Proof load (kN) | Breaking load (kN) |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 36 | 366 | 523 | 523 | 732 | 732 | 1050 |
| 38 | 406 | 581 | 581 | 812 | 812 | 1160 |
| 40 | 448 | 640 | 640 | 896 | 896 | 1280 |
| 42 | 492 | 703 | 703 | 981 | 981 | 1400 |
| 44 | 583 | 769 | 769 | 1080 | 1080 | 1540 |
| 46 | 585 | 837 | 837 | 1170 | 1170 | 1680 |
| 48 | 635 | 908 | 908 | 1270 | 1270 | 1810 |
| 50 | 686 | 981 | 981 | 1370 | 1370 | 1960 |
| 52 | 739 | 1060 | 1060 | 1480 | 1480 | 2110 |
| 54 | 794 | 1140 | 1140 | 1590 | 1590 | 2270 |
| 56 | 851 | 1220 | 1220 | 1710 | 1710 | 2430 |
| 58 | 909 | 1290 | 1290 | 1810 | 1810 | 2600 |
| 60 | 969 | 1380 | 1380 | 1940 | 1940 | 2770 |
| 62 | 1030 | 1470 | 1470 | 2060 | 2060 | 2940 |
| 64 | 1100 | 1560 | 1560 | 2190 | 2190 | 3130 |
| 66 | 1160 | 1660 | 1660 | 2310 | 2310 | 3300 |
| 68 | 1230 | 1750 | 1750 | 2450 | 2450 | 3500 |
| 70 | 1290 | 1840 | 1840 | 2580 | 2580 | 3690 |
| 73 | 1390 | 1990 | 1990 | 2790 | 2790 | 3990 |
| 76 | 1500 | 2150 | 2150 | 3010 | 3010 | 4300 |
| 78 | 1580 | 2260 | 2260 | 3160 | 3160 | 4500 |
| 81 | 1690 | 2410 | 2410 | 3380 | 3380 | 4820 |
| 84 | 1800 | 2580 | 2580 | 3610 | 3610 | 5160 |
| 87 | 1920 | 2750 | 2750 | 3850 | 3850 | 5500 |
| 90 | 2050 | 2920 | 2920 | 4090 | 4090 | 5840 |
| 92 | 2130 | 3040 | 3040 | 4260 | 4260 | 6080 |
| 95 | 2260 | 3230 | 3230 | 4510 | 4510 | 6440 |
| 97 | 2340 | 3340 | 3340 | 4680 | 4680 | 6690 |

**Table 2.9.1(b) : Test load values for stud link chain cables**

| Chain cable diameter (mm) | Grade CC1 | | Grade CC2 | | Grade CC3 | |
|---|---|---|---|---|---|---|
| | Proof load (kN) | Breaking load (kN) | Proof load (kN) | Breaking load (kN) | Proof load (kN) | Breaking load (kN) |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 100 | 2470 | 3530 | 3530 | 4940 | 4940 | 7060 |
| 102 | 2560 | 3660 | 3660 | 5120 | 5120 | 7320 |
| 105 | 2700 | 3850 | 3850 | 5390 | 5390 | 7700 |
| 107 | 2790 | 3980 | 3980 | 5570 | 5570 | 7960 |
| 111 | 2970 | 4250 | 4250 | 5940 | 5940 | 8480 |
| 114 | 3110 | 4440 | 4440 | 6230 | 6230 | 8890 |
| 117 | 3260 | 4650 | 4650 | 6510 | 6510 | 9300 |
| 120 | 3400 | 4850 | 4850 | 6810 | 6810 | 9720 |
| 122 | 3500 | 5000 | 5000 | 7000 | 7000 | 9990 |
| 124 | 3600 | 5140 | 5140 | 7200 | 7200 | 10280 |
| 127 | 3750 | 5350 | 5350 | 7490 | 7490 | 10710 |
| 130 | 3900 | 5570 | 5570 | 7800 | 7800 | 11140 |
| 132 | 4000 | 5720 | 5720 | 8000 | 8000 | 11420 |
| 137 | 4260 | 6080 | 6080 | 8510 | 8510 | 12160 |
| 142 | 4520 | 6450 | 6450 | 9030 | 9030 | 12910 |
| 147 | 4790 | 6840 | 6840 | 9560 | 9560 | 13660 |
| 152 | 5050 | 7220 | 7220 | 10100 | 10100 | 14430 |
| 157 | 5320 | 7600 | 7600 | 10640 | 10640 | 15200 |
| 162 | 5590 | 7990 | 7990 | 11170 | 11170 | 15970 |

**Table 2.9.2 : Number of mechanical test specimens for finished chain cables and accessories**

| Grade | Manufacturing method | Condition of supply 1) | Number of test specimens | | |
|---|---|---|---|---|---|
| | | | Tensile test for base metal | Charpy V-notch impact test | |
| | | | | Base metal | Weldment |
| CC1 | Flash-butt welded | AW<br>N | NR | NR | NR |
| CC2 | Flash-butt welded | AW<br>--------------------<br>N | 1<br>--------------------<br>NR | 3<br>--------------------<br>NR | 3<br>--------------------<br>NR |
| | Forged or Cast | N | 1 | 3 [2)] | NA |

| | | | | | |
|---|---|---|---|---|---|
| CC3 | Flash-butt welded | N<br>NT<br>QT | 1 | 3 | 3 |
| | Forged or Cast | N<br>NT<br>QT | 1 | 3 | NA |
| 1) AW = As Welded, N = Normalized, NT = Normalized and Tempered,<br>QT = Quenched and Tempered<br>2) For chain cables, Charpy V-notch impact test is not required.<br>NR = Not required<br>NA = Not applicable | | | | | |

**Table 2.9.3 : Mechanical properties of finished chain cables and accessories**

| Grade | Yield strength [N/mm$^2$] min. | Tensile strength [N/mm$^2$] min. | Elongation on 5.65 √So % min. | Reduction of area % min. | Charpy V-notch impact test | | |
|---|---|---|---|---|---|---|---|
| | | | | | Test tempera-ture, in C | Absorbed energy, in Joules min. | |
| | | | | | | Base metal | Weldment |
| CC1 | NR | NR | NR | NR | NR | NR | NR |
| CC2 | 295 | 490 – 690 | 22 | NR | 0 | 27 | 27 |
| CC3 | 410 | 690 min. | 17 | 40 | 0 [1)] | 60 | 50 |
| | | | | | -20 | 35 | 27 |

1) Testing is normally to be carried out at 0°C.

NR = Not required.

2.9.3 Sample lengths comprising of at least three links are to be taken from every four lengths or fraction of chain cables and tested at the breaking loads given in Table 2.9.1. The breaking load is to be maintained for a minimum of 30 seconds. The links concerned are to be made in a single manufacturing cycle together with the chain cable and must be welded and heat treated together with it. Only after this these may be separated from the chain cable in the presence of the Surveyor.

2.9.4 Where a breaking load test specimen fails, a further specimen is to be cut from the same length of cable and subjected to test. If this re-test fails, the length of cable from which it was taken is to be rejected. When this test is also representative of other lengths, each of the remaining lengths in the batch is to be individually tested and is to meet the requirements of the breaking load test.

2.9.5 For large diameter cables where the required breaking load is greater than the capacity of the testing machines, special consideration will be given to acceptance of other alternative testing procedure.

2.9.6 Mechanical test specimens required in Table 2.9.2 are to be taken from every four lengths in accordance with 2.9.7. For forged or cast chain cables where the batch size is less than four lengths, the sampling frequency is to be by heat treatment charge. Mechanical tests are to be carried out in the presence of the Surveyor. The test specimens and their location are to be according to 2.4.5 to 2.4.7 and Fig.2.4.1. Testing and re-testing are to be carried out as given in 2.4.9.

2.9.7 An additional link (or where the links are small, several links) for mechanical test specimen removal is to be provided in a length of chain cable not containing the specimen for the breaking test. The specimen link must be manufactured and heat treated together with the length of chain cable.

**2.10 Accessories for chain cables**

2.10.1 End and joining shackles, attachment links, adapter pieces, swivels and other fittings are to be subjected to the proof and breaking loads appropriate to the grade and size of cable for which they are intended in accordance with the requirements of Table 2.9.1.

2.10.2 The breaking load is to be applied to at least one item out of every 25 (one in 50 for lugless shackles). The items need not necessarily be representative of each heat of steel or individual purchase order. Enlarged links and end links need not be tested provided that they are manufactured and heat treated together with the chain cable. The tested item is to be destroyed and not used as part of an outfit, in general. However, the accessories, which have been successfully tested at the prescribed breaking load appropriate to the chain, may be used in service at the discretion of Designated Authority/Classification Society where the accessories are manufactured with the following:

a) material having higher strength characteristics than those specified for the part in question (e.g. grade 3 material for accessories for grade 2 chain).

b) or alternatively, same grade material as the chain but with increased dimensions and it is verified by procedure tests that such accessories are so designed that the breaking strength is not less than 1.4 times the prescribed breaking load of the chain for which they are intended.

2.10.3 The breaking load test may be waived if –

a) The breaking load has been demonstrated on the occasion of the approval testing of parts of the same design, and

b) The mechanical properties of each manufacturing batch are approved, and

c) The parts are subjected to suitable non-destructive testing.

2.10.4 Unless otherwise specified, the forging or casting must at least comply with the mechanical properties given in Table 2.9.3, when properly heat treated. For test sampling, forgings or castings of similar dimensions originating from the same heat treatment charge and the same heat of steel are to be combined into one test unit. From each test unit, one tensile test specimen and the Charpy V-notch impact test specimens are to be taken in accordance with Table 2.9.2. Mechanical tests are to be carried out in the presence of the Surveyor. Location of test specimens and test procedure are to be as given in 2.4.5 to 2.4.7 and Fig.2.4.1. Testing / re-testing is to be carried out as per 2.4.9. Enlarged links and end links need not be tested provided they are manufactured and heat treated together with the chain cable.

**2.11 Identification**

2.11.1 All lengths of cables and accessories are to be stamped with the following identification marks:-

a) Brand mark and the abbreviated name of the Designated Authority/Classification Society issuing the certificate;

b) Number of certificate;

c) Date of test;

d) Proof load and grade of chain;

e) Personal stamp of the Surveyor responsible for inspection.

## Section 3

## Short Link Chain Cables

**3.1 General**

3.1.1 Details regarding the form and proportions of short link chain cable, materials, method of manufacture and testing are to be submitted for special consideration by Designated Authority/Classification Society.

3.1.2 In general the short link chain cables are to comply with the grades L(3) and M(4) of ISO 1834.

**3.2 Testing and inspection of chain cables**

3.2.1 All chain cable of 12.5 [mm] diameter and above, and all steering chains irrespective of diameter are to be tested at a proving establishment recognised by Designated Authority/Classification Society.

3.2.2 For chain of diameter less than 12.5 [mm], other than steering chains, the manufacturer's tests will be accepted.

3.2.3 After completion of all manufacturing processes, including heat treatment and galvanising, the whole of the chain is to be subjected to the appropriate proof load specified in Table 3.2.1.

3.2.4 The whole of the chain is to be inspected after the proof load test and is to be free from significant defects.

3.2.5 At least one sample, consisting of seven or more links, is to be selected by the Surveyor from each 200 [m] or less of chain for breaking load tests. Two additional links may be required for engagement in the jaws of the testing machine. These extra links are not to be taken into account in determining the total elongation (See 3.2.7).

3.2.6 The breaking load is to comply with the appropriate requirements of Table 3.2.1.

3.2.7 The total elongation of the breaking load sample at fracture, expressed as a percentage of the original inside length of the sample after proof loading, is to be not less than 20 per cent.

| Table 3.2.1 : Mechanical test requirements for short link chain cables | | | | |
|---|---|---|---|---|
| **Chain diameter [mm]** | **Grade L(3)** | | **Grade M(4)** | |
| | **Proof load [kN]** | **Breaking load min. [kN]** | **Proof load [kN]** | **Breaking load min. [kN]** |
| 5 | - | - | 7.9 | 15.8 |
| 6 | 9 | 18 | - | - |
| 6.3 | - | - | 12.5 | 25 |
| 7.1 | - | - | 15.9 | 31.8 |
| 8 | 16 | 32 | 20.2 | 40.4 |
| 9 | - | - | 25.5 | 51 |
| 10 | 25 | 50 | 31.5 | 63 |
| 11.2 | - | - | 39.5 | 79 |
| 12 | 35.5 | 71 | - | - |
| 12.5 | - | - | 49.1 | 98.2 |
| 14 | - | - | 63 | 126 |
| 16 | - | - | 81 | 162 |
| 18 | - | - | 102 | 204 |
| 20 | - | - | 126 | 252 |
| 22.4 | - | - | 158 | 316 |
| 25 | - | - | 197 | 394 |
| 28 | - | - | 247 | 494 |
| 32 | - | - | 322 | 644 |
| 36 | - | - | 408 | 816 |
| 40 | - | - | 503 | 1006 |
| 45 | - | - | 637 | 1274 |

**Section 4**

**Steel Wire Ropes**

**4.1 General**

4.1.1 Steel wire ropes are to be manufactured at Works approved by Designated Authority/ Classification Society. Also refer Chapter 1, Section 1, Cl. 1.3.2.

4.1.2 The wire ropes are to be of six strand type with minimum of 16 wires in each strand. In addition to complying with the requirements of this Chapter, the details regarding form of construction and minimum breaking strength are to be in accordance with IS: 2266-1989. Alternative type of wire ropes will be specially considered on the basis of an equivalent breaking load and the suitability of the construction for the purpose intended.

4.1.3 It is recommended that the wire ropes intended for stream wires, towlines and mooring lines be of fiber core construction and wire ropes for towlines and mooring lines used in association with mooring winches be of wire rope core.

**4.2 Materials**

4.2.1 The wire used in the manufacture of the rope is to be drawn from steel made in accordance with the requirements of Ch.3.

| Table 4.2.1 : Torsion test - Speed of testing | |
|---|---|
| Diameter of coated wire [mm] | Maximum speed of testing twists per minute |
| $< 1.5$ | 90 |
| $\geq 1.5 < 3.0$ | 60 |
| $\geq 3.0 < 4.0$ | 30 |

4.2.2 The tensile strength is generally to be within the ranges 1420 to 1570 [N/mm$^2$]; 1570 to 1770 [N/mm$^2$] or 1770 to 1960 [N/mm$^2$].

4.2.3 The wire is to be galvanized by a hot dip or electrolytic process to give a uniform coating which may be any of the following grades:-

Grade 1 : heavy coating, drawn after galvanizing;

Grade 2 : heavy coating, finally galvanized;

Grade 3 : light coating, drawn after galvanizing.

4.2.4 Torsion and zinc coating tests are to be carried out on wire samples taken from a suitable length of the completed rope. After unstranding and straightening, six wires are to be subjected to both a torsion test and a wrap test for adhesion of coating. Additionally, tests to determine the uniformity of the zinc coating are to be carried out.

4.2.5 As an alternative to test specimens taken as detailed in 4.2.4, tests may be carried out on the wire before the rope is stranded.

4.2.6 For the torsion test, the length of the sample is to be such as to allow a length between the grips of 100 times the wire diameter or 300 [mm], whichever is less. The wire is to be twisted by causing one or both of the vices to be revolved until fracture occurs. The speed of testing is not to exceed, for a length equal to 100 times the diameter, that given in Table 4.2.1 (a tensile load not exceeding 2 per cent of the breaking load of the wire may be applied to keep the wire stretched). The wire is to withstand, without fracture on a length of 100 times the diameter of wire, the number of complete twists given in Table 4.2.2.

**Table 4.2.2 : Torsion test - Minimum number of twists**

| Diameter of coated wire [mm] | Minimum number of twists | | | |
|---|---|---|---|---|
| | Grade 2 | | Grade 1 or 3 | |
| | Tested before stranding | Tested after stranding | Tested before stranding | Tested after stranding |
| < 1.3 | 15 | 13 | 27 | 24 |
| ≥ 1.3 < 2.3 | 15 | 13 | 26 | 23 |
| ≥ 2.3 < 3.0 | 14 | 12 | 23 | 20 |
| ≥ 3.0 < 4.0 | 12 | 10 | 21 | 18 |

**4.3 Zinc coating tests**

4.3.1 The mass per unit area of the zinc coating is to be determined in accordance with a recognised standard and is to comply with the minimum values given in Table 4.3.1.

**Table 4.3.1 : Zinc coating**

| Diameter of coated wire [mm] | Zinc coating [grams/m$^2$] | |
|---|---|---|
| | Grade 1 or 2 | Grade 3 |
| ≥ 0.40 < 0.50 | 75 | 40 |
| ≥ 0.50 < 0.6 | 90 | 50 |
| ≥ 0.6 < 0.8 | 110 | 60 |
| ≥ 0.8 < 1.0 | 130 | 70 |
| ≥ 1.0 < 1.2 | 150 | 80 |
| ≥ 1.2 < 1.5 | 165 | 90 |
| ≥ 1.5 < 1.9 | 180 | 100 |
| ≥ 1.9 < 2.5 | 205 | 110 |
| ≥ 2.5 < 3.2 | 230 | 125 |
| ≥ 3.2 < 4.0 | 250 | 135 |

4.3.2 The uniformity of the zinc coating is to be determined by a dip test carried out in accordance with the requirements of a recognized standard.

4.3.3 The adhesion of the coating is to be tested by wrapping the wire round a cylindrical mandrel for 10 complete turns. The ratio between the diameter of the mandrel and that of the wire is to be as in Table 4.3.2. After wrapping on the appropriate mandrel the zinc coating is to have neither flaked nor cracked to such an extent that any zinc can be removed by rubbing with bare fingers.

| Table 4.3.2 : Wrap test for adhesion of zinc coating | | |
|---|---|---|
| **Coating** | **Diameter coated wire [mm]** | **Max. ratio of mandrel to wire diameter** |
| Grade 1 and 2 | < 1.5 | 4 |
| | ≥ 1.5 | 6 |
| Grade 3 | < 1.5 | 2 |
| | ≥ 1.5 | 3 |

**4.4 Test on completed ropes**

4.4.1 The breaking load is to be determined by testing to destruction a sample cut from the completed rope. This sample is to be of sufficient length to provide a clear test length of at least 36 times the rope diameter between the grips.

4.4.2 The actual breaking load is not to be less than that given in the appropriate approved standard.

**4.5 Identification**

4.5.1 All completed ropes are to be identified with attached labels detailing the rope type, diameter and length.

## Chapter 11

## Approval of Welding Consumables for Use in Ship Construction

**Contents**

**Section**



### Section 1

### General

**1.1 Scope**

1.1.1 This Chapter gives the requirements for approval and inspection of welding consumables such as electrodes, wires, fluxes etc. intended for welding of the following types of materials used in ship construction:

(b) Normal strength steel for ship structures, Grades A, B, D and E (See Ch.3).

(c) Higher strength steels for ship structures Grades AH32, DH32, EH32, AH36, DH36 and EH36 (See Ch.3).

(d) Higher strength steels for ship structures with minimum yield strength 390 [N/mm$^2$] : Grades AH40, DH40 and EH40 (See Ch.3).

(e) Higher strength steels for ship structures for low temperature application : Grades FH32, FH36 and FH40 (See Ch.3).

(f) Higher strength steels for welded structures.

(g) Aluminium alloys (See Ch.9).

**1.2 Manufacture**

1.2.1 The manufacturer's plant and method of production of welding consumables are to be such as to ensure reasonable uniformity in manufacture. Designated Authority/Classification Society is to be notified of any alteration proposed to be made in the process of manufacture subsequent to approval.

**1.3 Grading**

1.3.1 Welding consumables for steel materials specified in 1.1.1 a) to d) above.

These consumables are divided into 3 strength groups each of which is further graded as per the Charpy V-notch impact test requirements as shown below:

| **Groups** | **Grading** |
|---|---|
| Normal strength steel | 1, 2, 3 |
| Higher strength steel : yield strength upto 355 [N/mm$^2$] | 1Y, 2Y, 3Y, 4Y |
| Higher strength steels : yield strength upto 390 [N/mm$^2$] | 2Y40, 3Y40, 4Y40, 5Y40 |
| Hydrogen marks<br>Welding consumables of Grades 2 and 3; and of Grades 2Y, 3Y and 4Y and of Grades 2Y40, 3Y40, 4Y40 and 5Y40 for which hydrogen content has been controlled in accordance with Sec.2.5 are identified by the mark H15, H10 or H5 | |
| The following suffixes are added after the Grade mark as applicable:<br>S : Semi-automatic<br>T : Two-run technique<br>M : Multi-run technique<br>TM : Both two-run and multi-run technique<br>V : Vertical | |

See Table 1.3.1 for correlation of welding consumables to hull structural steel grades.

1.3.2 For grading of consumables for welding higher strength quenched and tempered steels indicated in 1.1.1 e) above, refer to Sec. 7.

1.3.3 For grading of consumables for welding aluminium alloys indicated in 1.1.1 f) above, refer to Sec.8.

**Table 1.3.1 : Correlation of welding consumables to hull structural steel grades**

| **Grades of Welding Consumables (see notes)** | **Hull structural steel Grades** [1] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **A** | **B** | **D** | **E** | **AH32/36** | **DH32/36** | **EH32/36** | **FH32/36** | **AH40** | **DH40** | **EH40** | **FH40** |
| 1, 1S, 1T, 1M, 1TM, 1V | X | | | | | | | | | | | |
| 1YS, 1YT, 1YM, 1YTM, 1YV | X | | | | X [3] | | | | | | | |
| 2, 2S, 2T, 2M, 2TM, 2V | X | X | X | | | | | | | | | |
| 2Y, 2YS, 2YT, 2YM, 2YTM, 2YV | X | X | X | X | X | | | | | | | |
| 2Y40, 2Y40S, 2Y40T, 2Y40M, 2Y40TM, 2Y40V | 2) | 2) | 2) | | X | X | | | X | X | | |
| 3, 3S, 3T, 3M, 3TM, 3V | X | X | X | X | | | | | | | | |
| 3Y, 3YS, 3YT, 3YM, 3YTM, 3YV | X | X | X | X | X | X | X | | | | | |
| 3Y40, 3Y40S, 3Y40T, 3Y40M, 3Y40TM, 3Y40V | 2) | 2) | 2) | 2) | X | X | X | | X | X | X | |
| 4Y, 4YS, 4YT, 4YM, 4YTM, 4YV | X | X | X | X | X | X | X | X | | | | |
| 4Y40, 4Y40S, 4Y40T, 4Y40M, 4Y40TM, 4Y40V | 2) | 2) | 2) | 2) | X | X | X | X | X | X | X | X |
| 5Y40, 5Y40S, 5Y40T, 5Y40M, 5Y40TM, 5Y40V | 2) | 2) | 2) | 2) | X | X | X | X | X | X | X | X |

1) Requirements for other grades of steels given in ch.3 but not included here will be specially considered.

2) See Note d)

3) See Note e)

(a) When joining normal to higher strength structural steel, consumables of the lowest acceptable grade for either material being joined may be used.

(b) When joining steels of same strength level but of different toughness grade, consumables of the lowest acceptable grade for either material being joined may be used.

(c) It is recommended that controlled low hydrogen type consumables are to be used when joining higher strength structural steels to the same or lower strength level, except that other consumables may be used when the carbon equivalent is below or equal to 0.41%. When other than controlled low hydrogen type electrodes are used appropriate procedure test for hydrogen cracking may be conducted subject to approval of Designated Authority/Classification Society.

(d) The welding consumables approved for steel Grades AH40, DH40, EH40 and/or FH40 may also be used for welding of the corresponding grades of normal strength steels subject to the approval of Designated Authority/Classification Society.

(e) When joining higher strength steels using Grade 1Y welding consumables, the material thicknesses is not to exceed 25 [mm].

**1.4 Approval procedure**

1.4.1 Approval of welding consumables will be considered on the basis of the manufacturer's description of the works and detailed description of the method of production control, satisfactory inspection of the works by the Surveyors and compliance with the test requirements detailed in subsequent paragraphs of this Chapter.

1.4.2 When a welding consumable is manufactured in several locations of the same company, the complete series of approval tests would be carried out in one Works only. In other locations, a reduced test programme based upon the requirements of annual testing may be accepted subject to the manufacturer certifying that the materials and the fabrication process used are identical with those of the main unit.

This requirement is also applicable to all manufacturers of welding consumables under license.

Note : In case of wire flux combination for submerged arc welding where a unique powder flux is combined with different wires coming from several factories belonging to the same firm only one test series may be carried out provided the wires conform to the same technical specification.

1.4.3 The test assemblies are to be prepared under the supervision of the Surveyor, and all tests are to be carried out in his presence.

1.4.4 Designated Authority/Classification Society may require, in any particular case, such additional tests or spacing requirements as may be necessary.

**1.5 Test assemblies**

1.5.1 The test assemblies are to be prepared and tested under the supervision of the Surveyor(s).

1.5.2 When a welded joint is performed, the edges of the plates are to be bevelled either by mechanical machining or by oxygen cutting; in the latter case, a descaling of the edges is necessary.

1.5.3 The welding conditions used such as amperage, voltage, travel speed, etc. are to be within the range recommended by the manufacturer for normal and good welding practice. Where a welding consumable is suitable for both alternating current (AC) and direct current (DC), AC is to be used for the preparation of test assemblies.

**1.6 Annual inspection and tests**

1.6.1 All establishments, where approved welding consumables are manufactured, and the associated quality control procedures, are to be subjected to annual inspection. On these occasions, samples of the approved consumables are to be selected by the Surveyor and subjected to the tests detailed in the subsequent paragraphs of this Chapter.

**1.7 Upgrading and uprating**

1.7.1 Upgrading and uprating of welding consumables will be considered only at the manufacturer's request, preferably at the time of annual testing. Generally, for this purpose, tests from butt weld assemblies will be required in addition to the normal annual approval tests.

1.7.2 Upgrading refers to notch toughness of the welding consumable while uprating refers to extension to cover higher strength level steels.

1.7.3 Any alteration to the approved consumable which may result in a change in the chemical composition and the mechanical properties of the deposited metal, must be immediately notified by the manufacturer. Additional tests may be necessary.

**1.8 Dimensions of test specimens**

1.8.1 Deposited metal tensile test specimens are to be machined to the dimensions shown in Fig.1.8.1. Care is to be taken to ensure that the longitudinal axis of the test piece coincides with the centre of the weld and midthickness of the plates. The test piece may be heated to a temperature not exceeding 250°C for a

period not exceeding 16 hours for hydrogen removal, prior to testing.

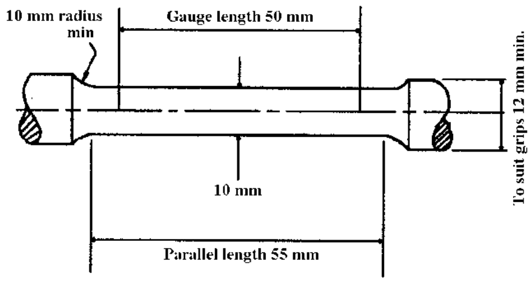



**Fig.1.8.1 : Deposited metal tensile test**

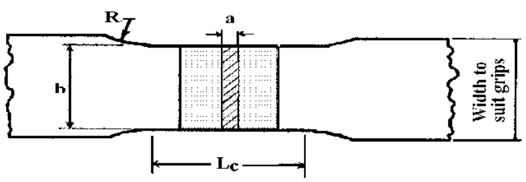



**Fig.1.8.2 : Butt weld tensile test specimen**

1.8.2 Butt weld tensile test specimens are to be machined to the following dimensions (see Fig.1.8.2).

a = thickness of plate 't'

b = 12 for t ≤ 2 [mm]

= 25 for t > 2 [mm]

$L_c$ = width of weld + 60 [mm]

R > 25 [mm].

The upper and lower surfaces of the weld are to be filed, ground or machined flush with the surface of the plates.

1.8.3 Butt weld bend test specimens are to be 30 [mm] in width. Upper and lower surfaces of the weld are to be filed, ground or machined flush with the surfaces of the plates and sharp corners of the specimens are to be rounded to a radius not exceeding 2 [mm].

1.8.4 All impact test specimens are to be of the standard 10 [mm] x 10 [mm] Charpy V-notch type, machined to the dimensions and tolerances detailed in Ch.2.

**1.9 Testing procedures**

1.9.1 The procedures used for all tensile and impact tests are to comply with the requirements of Ch.2.

1.9.2 Butt weld bend test specimens are to be tested at ambient temperature. The test specimens are to be capable of withstanding, without fracture, being bent through an angle of 120 degrees over a former having a diameter three times the thickness of the specimen. One specimen from each welded assembly is to be tested with the face of the weld in tension and the other with the root of the weld in tension.

The test pieces can be considered as complying with the requirements if, on completion of the test, no crack or defect at the outer surface of the test specimen can be seen.

1.9.3 Tensile Tests : On deposited metal test specimens, the values of tensile strength, yield stress and elongation are to be recorded. On butt weld specimens, the values of tensile strength and the position of fracture are to be recorded.

1.9.4 Charpy V-notch Impact Tests : A set of three test specimens is to prepared and tested. The average absorbed energy value is to comply with the requirements of subsequent sections. One individual value may be less than the required average value provided that it is not less than 70 per cent of this value.

The test temperature for Grades 2, 2Y, 2Y40, 3, 3Y, 3Y40, 4Y, 4Y40 and 5Y40 test pieces is to be controlled within ±2°C of the prescribed temperature.

**1.10 Re-test procedures**

1.10.1 Where the results of a tensile or bend test do not comply with the requirements, duplicate test specimens of the same type are to be prepared and are to be satisfactorily tested. Where insufficient original welded assembly is available, a new assembly is to be prepared using welding consumables from the same batch. If the new assembly is made with the same procedure (particularly the number of runs) as the original assembly, only the duplicate re-test specimens need to be tested. Otherwise, all test specimens are to be prepared and re-tested.

1.10.2 Where the results from a set of three impact test specimens do not comply with the requirements, an additional set of three impact test specimens may be taken provided that not more than two individual values are less than the required average value and, of these, not more than one is less than 70 per cent of the average value. The results obtained are to be combined with the original results to form a new average which, for acceptance, is to be not less than the required value. Additionally, for these combined results not more than two individual values are to be less than the required average value, and of these, not more than one is to be less than 70 per cent of the average value. Further retests may be made at the Surveyor's discretion, but these must be made on a new welded assembly and must include all tests required for the original assembly, even those which were previously satisfactory.

**1.11 Chemical composition**

1.11.1 The chemical analysis of the weld metal made by the electrode is to be supplied by the manufacturer.

## Section 2

## Electrodes for Normal Penetration Manual Welding

### 2.1 General

2.1.1 Based on the results of the Charpy V-notch impact tests, electrodes are divided into the following grades:-

For normal strength steel - Grades 1, 2 and 3

For higher strength steel with minimum yield strength upto 355 [N/mm$^2$] - Grades 2Y, 3Y and 4Y. (Grade 1Y not applicable for manual welding).

For higher strength steels with minimum yield strength upto 390 [N/mm$^2$] - Grades 2Y40, 3Y40, 4Y40 and 5Y40.

2.1.2 If the electrodes are in compliance with the requirements of the hydrogen test given in 2.5, a suffix H15, H10 or H5 will be added to the grade mark.

2.1.3 For initial approval the tests specified in this Section including hydrogen test, if applicable, are to be carried out.

### 2.2 Deposited metal tests

2.2.1 Two deposited metal test assemblies are to be prepared in the downhand position as shown in Fig.2.2.1, one using 4 [mm] electrodes and the other using the largest size manufactured. If an electrode is manufactured in one diameter only, one test assembly is sufficient. Any grade of ship structural steel may be used for the preparation of these test assemblies.

2.2.2 The weld metal is to be deposited in single or multi-run layers according to normal practice and the direction of each layer is to alternate from each end of the plate, each run of the weld metal being not less than 2 [mm] and not more than 4 [mm] thick. Between each run the assembly is to be left in still air until it has cooled to 250°C but not less than 100°C, the temperature being taken in the centre of the weld, on the surface of the seam. After being welded the test assemblies are not to be subjected to any heat treatment.

2.2.3 One tensile and three impact test specimens are to be taken from each test assembly as shown in Fig.2.2.1. The impact test specimens are to be cut perpendicular to the weld, with their axes 10 [mm] from the upper surface of the plate. The notch is to be positioned in the centre of the weld and cut in the face of the test specimen perpendicular to the surface of the plate.

2.2.4 The chemical analysis of the deposited weld metal in each test assembly is to be supplied by the manufacturer and is to include the content of all significant alloying elements.

2.2.5 The results of all tests are to comply with the requirements of Table 2.2.1 as appropriate.

**Table 2.2.1 : Requirements for deposited metal tests (covered electrodes)**

| Grade | Yield stress [N/mm$^2$] min. | Tensile strength [N/mm$^2$] | Minimum elongation on 50 mm gauge length [%] | Impact Tests | |
|---|---|---|---|---|---|
| | | | | Test temp. °C | Average energy J min. |
| 1 | 305 | 400 - 560 | 22 | 20 | 47 |
| 2 | | | | 0 | |
| 3 | | | | -20 | |
| 2Y | 375 | 490 - 660 | 22 | 0 | 47 |
| 3Y | | | | -20 | |
| 4Y | | | | -40 | |
| 2Y40 | 400 | 510 - 690 | 22 | 0 | 47 |
| 3Y40 | | | | -20 | |
| 4Y40 | | | | -40 | |
| 5Y40 | | | | -60 | |

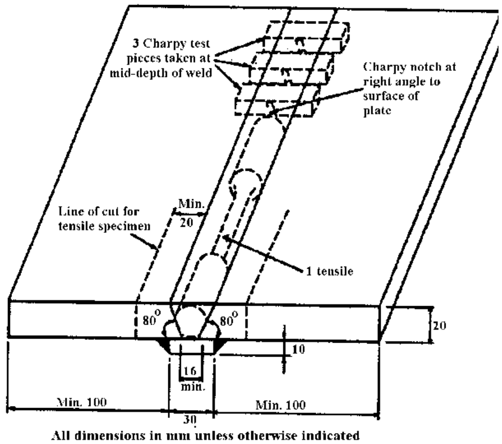



**Fig.2.2.1 : Deposited metal test assembly**

**2.3 Butt weld tests**

2.3.1 Butt weld assemblies as shown in Fig.2.3.1 are to be prepared for each welding position (downhand, horizontal-vertical, vertical-upward, vertical-downward and overhead) for which the electrode is recommended by the manufacturer, except that electrodes satisfying the requirements for downhand and vertical-upward positions will be considered as also complying with the requirements for the horizontal-vertical position.

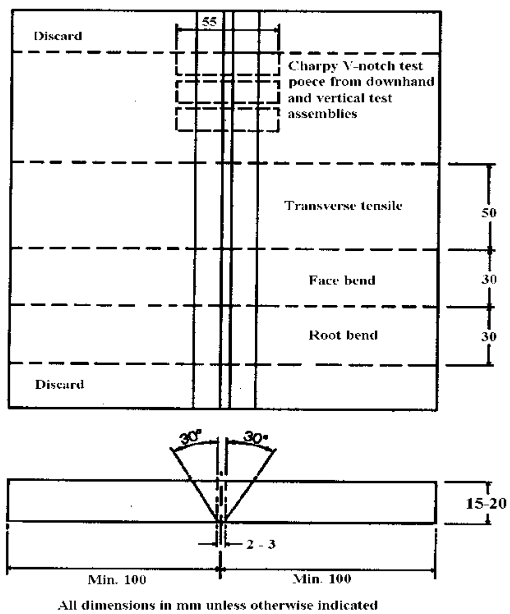



**Fig.2.3.1 : Butt weld test assembly**

**Table 2.3.1 : Requirements for butt weld test (covered electrodes)**

| Grade | Tensile strength [N/mm$^2$] min. (transverse test) | Charpy V-notch impact test | | |
|---|---|---|---|---|
| | | Test temp. °C | Average energy J min. | |
| | | | Down-hand horizon-tal vertical, over-head | Vertical (upward and down-ward) |
| 1 | | 20 | | |
| 2 | 400 | 0 | 47 | 34 |
| 3 | | -20 | | |

| | | | | |
|---|---|---|---|---|
| 2Y<br>3Y<br>4Y | 490 | 0<br>-20<br>-40 | 47 | 34 |
| 2Y40<br>3Y40<br>4Y40<br>5Y40 | 510 | 0<br>-20<br>-40<br>-60 | 47 | 39 |

2.3.2 Where the electrode is only to be approved in the downhand position an additional test assembly is to be prepared in that position.

2.3.3 The grades of steels used for the preparation of the test assemblies are to be as follows:

| | |
|---|---|
| Grade 1 electrodes | A |
| Grade 2 electrodes | A, B, D |
| Grade 3 electrode | A, B, D, E |
| Grade 2Y electrode | AH32, AH36, D32, D36 |
| Grade 3Y electrode | AH32, AH36, DH32, DH36, EH32, EH36 |
| Grade 4Y electrodes | AH32, AH36, DH32, DH36, EH32, EH36, FH32, FH36 |
| Grade 2Y40 electrodes | AH40, DH40 |
| Grade 3Y40 electrodes | AH40, DH40, EH40 |
| Grade 4Y40 electrodes | AH40, DH40, EH40, FH40 |
| Grade 5Y40 electrodes | AH40, DH40, EH40, FH40 |

2.3.4 Where higher strength steel with minimum yield strength 315 [N/mm$^2$] is used for grade 2Y, 3Y and 4Y electrodes, the actual tensile strength of the steel is to be not less than 490 [N/mm$^2$]. The chemical composition including the content of grain refining elements is to be reported.

2.3.5 The following welding procedure should be adopted in making the test assemblies:-

**DOWNHAND (a)**

First run with 4 [mm] diameter electrode. Remaining runs (except last two layers) with 5 [mm] diameter electrodes or above according to the normal welding practice with the electrodes. The runs of the last two layers with the largest size of electrode manufactured.

**DOWNHAND (b)**

Where a second downhand test is required:-

First run with 4 [mm] diameter electrode. Next run with an intermediate size electrode 5 [mm] or 6 [mm] diameter and the remaining runs with the largest size of electrode manufactured.

**HORIZONTAL-VERTICAL**

First run with 4 [mm] or 5 [mm] diameter electrode, subsequent runs with 5 [mm] diameter electrodes.

**VERTICAL UPWARDS AND OVERHEAD**

First run with 3.25 [mm] diameter electrode. Remaining runs with 4 [mm] diameter electrodes or possibly 5 [mm] diameter electrodes if this is recommended by the manufacturer for the positions concerned.

**VERTICAL DOWNWARD**

The method to be adopted is to be as recommended by the manufacturer.

2.3.6 In all cases the back sealing runs are to be made with 4 [mm] diameter electrodes in the welding position appropriate to each test sample after cutting out the root run to clean metal. For electrodes suitable for downhand welding only, the test assemblies may be turned over to carry out the back sealing run.

2.3.7 The butts are to be welded using normal welding practice and between each run the assembly is to be left in still air until it has cooled to 250°C but not below 100°C, the temperature being taken in the centre of the weld, on the surface of the seam.

2.3.8 After being welded, the test assemblies are not to be subjected to any heat treatment.

2.3.9 It is recommended that the welded assemblies be subjected to a radiographic examination to ascertain any defects in the weld prior to testing.

2.3.10 From each test assembly one tensile, one face and one root bend and a set of three Charpy V-notch test specimens are to be prepared, except that the impact test specimens need not be prepared for test assemblies welded in the overhead position.

2.3.11 The results of all mechanical testing are to comply with the requirements of Table 2.3.1. The position of the fracture in the transverse tensile test is to be reported. The bend test specimens can be considered as complying with the requirements if, after bending, no crack or defect having dimensions

exceeding 3 [mm] can be seen on the outer surface of the test specimen.

**2.4 Fillet weld tests**

2.4.1 When an electrode is submitted for approval for fillet welding only and to which butt weld tests, as per 2.3, are not considered applicable, the initial approval tests are to consist of the fillet weld test, described herein, and the deposited metal test as per 2.2. When the electrode is submitted for approval for both butt and fillet welding, the initial approval is to include one fillet weld test as detailed hereunder and welded in the horizontal-vertical position in addition to the tests required by 2.2 and 2.3.

2.4.2 Fillet weld assemblies as shown in Fig.2.4.1 are to be prepared for each welding position (horizontal-vertical, vertical-upwards, vertical- downwards or overhead) for which the electrode is recommended by the manufacturer. The grade of steel used is to be in accordance with 2.3.3 as appropriate. The test assemblies are to be welded using an electrode of a diameter recommended by the manufacturer. The length of the test assembly, L, is to be sufficient to allow at least the deposition of the entire length of the electrode being tested.

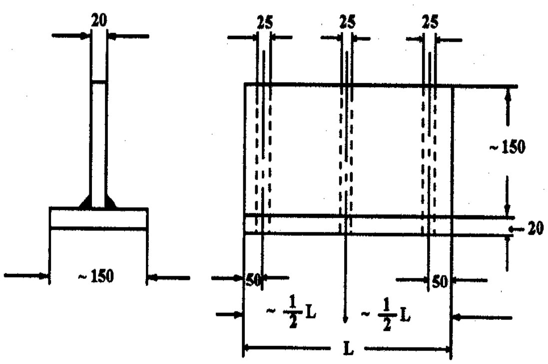



**Fig.2.4.1 : Fillet weld test assembly**

The first side is to be welded using the maximum size of electrode manufactured and the second side is to be welded using the minimum size of electrode manufactured and recommended for fillet welding. The fillet size will in general be determined by the electrode size and the welding current employed during testing.

2.4.3 The assembly is to be sectioned to form three macro sections each about 25 [mm] thick and the hardness readings are to be made in each section as indicated in Fig.2.4.2. The hardness of the weld is to be determined and is to meet the following listed equivalent values:-

(a) Diamond Pyramid Hardness (98 N load) = 150 minimum

(b) Rockwell (980 N load) B = 80 minimum

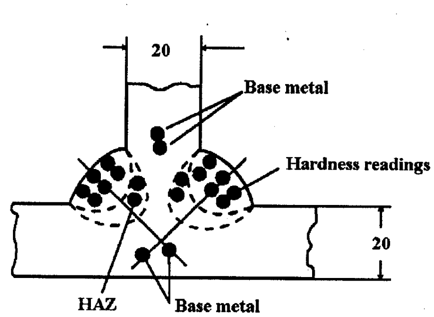



**Fig.2.4.2 : Hardness tests for fillet weld test**

2.4.4 The hardness of both heat affected zone and base metal is also to be determined and is to be reported for information.

2.4.5 One of the remaining sections of the assembly is to have the weld on the first side gouged or machined to facilitate breaking the fillet weld on the second side by closing the two plates together, subjecting the root of the weld to tension. On the other remaining section the weld on the second side is to be gouged or machined and the section fractured using the same procedure. The fractured surfaces are to be examined and there should be no evidence of incomplete penetrations, nor internal cracking and they should be reasonably free from porosity.

**2.5 Hydrogen test**

2.5.1 At the request of the manufacturer, electrodes may be submitted to a hydrogen test. A suffix H15, H10 or H5 will be added to the grade number to indicate compliance with the requirements of this test.

2.5.2 The mercury method or thermal conductivity detector method according to standard ISO 3690:2018 is to be used. Four weld assemblies are to be prepared. The temperature of the specimens and minimum holding time are to be complied with following, according to the measuring method respectively:

| Measuring Method | | Test Temp (° C) | Minimum Holding Time |
|---|---|---|---|
| Thermal Conductivity Detector Method [1] | Gas Chromatography | 45 | 72 |
| | | 150 | 6 |
| Note 1 - The use of hot carrier gas extraction method may be considered subject to verification of the testing procedure to confirm that collection and measurement of the hydrogen occurs continuously until all of the diffusible hydrogen is quantified. | | | |

Alternatively, the glycerine method as described below is to be used.

2.5.3 Glycerine method

(a) Four test specimens are to be prepared measuring 12 x 25 [mm] in cross- section by about 125 [mm] in length. The parent metal may be any grade of ship building steel and, before welding, the specimens are to be weighed to the nearest 0.1 gram. On the 25 [mm] surface of each test specimen a single bead of welding is to be deposited about 100 [mm] in length by a 4 [mm] electrode using about 150 [mm] of the electrode. The welding is to be carried out with as short an arc as possible and with a current of about 150 amperes. The electrode prior to welding, can be submitted to the normal drying process recommended by the manufacturer.

(b) Within thirty seconds of the completion of welding of each specimen the slag is to be removed and the specimen quenched in water at approximately 20°C. After a further thirty seconds the specimens are to be cleaned and placed in an apparatus suitable for the collection of hydrogen by displacement of glycerine. The glycerine is to be kept at a temperature of 45°C during the test. All the four specimens are to be welded and placed in the hydrogen collecting apparatus within 30 minutes.

(c) The specimens are to be kept immersed in the glycerine for a period of 48 hours and, after removal, are to be cleaned in water and spirit, dried and weighed to the nearest 0.1 gram to determine the amount of weld deposited. The amount of gas evolved is to be measured to the nearest 0.05 [$cm^3$] and corrected for temperature and pressure to 20C and 760 [mm] Hg.

2.5.4 The individual and average diffusible hydrogen contents of the four specimens are to be reported, and the average value in [$cm^3$] per 100 grams is not to exceed the following:

<table>
<tr><th>Mark</th><th>Diffusible Hydrogen Contents</th><th>Measuring Method</th></tr>
<tr><td>H15</td><td>15[1]</td><td>Mercury Method</td></tr>
<tr><td>H10</td><td>10[2]</td><td>Thermal Conductivity Detector Method<br>Glycerine Method</td></tr>
<tr><td>H5</td><td>5</td><td>Mercury Method<br>Thermal Conductivity Detector Method</td></tr>
<tr><td colspan="3">1 – 10 $cm^3$ per 100 gms where the glycerine method is used</td></tr>
<tr><td colspan="3">2 – 5 $cm^3$ per 100 gms where the glycerine method is used</td></tr>
<tr><td colspan="3">Note :- The glycerine method is not to be used for welding consumables with H5 mark.</td></tr>
</table>

**2.6 Covered electrodes for gravity or contact welding**

2.6.1 Where an electrode is submitted solely for approval for use in contact welding using automatic gravity or similar welding devices, deposited metal tests (see 2.2), fillet weld tests (see 2.4) and, where appropriate, butt weld tests (see 2.3) similar to those for normal manual electrodes are to be carried out using the process for which the electrode is recommended by the manufacturer.

2.6.2 Where an electrode is submitted for approval for use in contact welding using automatic gravity or similar welding devices in addition to normal manual welding, fillet weld tests (see 2.4) and, where appropriate, butt weld tests (see 2.3) similar to those for normal manual electrodes are to be carried out using the process for which the electrode is recommended by the manufacturer and these tests are to be in addition to the normal approval tests.

2.6.3 In the case of approval of a fillet welding electrode using automatic gravity or similar contact welding devices, the fillet welding is to be carried out using the welding process recommended by the manufacturer, with the longest size of electrode manufactured. The manufacturer's recommended current range is to be reported for each electrode.

2.6.4 Where approval is requested for the welding of both normal strength and higher tensile steels, the assemblies are to be prepared using higher tensile steel.

**2.7 Annual tests**

2.7.1 For normal penetration electrodes, the annual tests are to consist of two deposited metal test assemblies. These are to be prepared and tested in accordance with 2.2. If an electrode is available in one diameter only, one test assembly is sufficient.

2.7.2 Where an electrode is approved solely for gravity or contact welding, the annual test is to consist of one deposited metal test assembly using the gravity or other contact device as recommended by the manufacturer.

**2.8 Upgrading and uprating**

2.8.1 Upgrading and uprating will be considered only at the manufacturer's request and preferably at the time of annual testing. Tests on butt weld assemblies, in addition to the requirements of annual testing, are to be carried out.

**2.9 Certification**

2.9.1 Each carton or package of approved electrode is to contain a certificate from the manufacturer generally in accordance with the following:-

*"The .......... company certifies that composition and quality of these electrodes conform with those of the electrodes used in making the test pieces submitted to and approved by Indian Register of Shipping."*

## Section 3

## Deep Penetration Electrodes for Manual Welding

### 3.1 General

3.1.1 Where an electrode is designed solely for the deep penetration welding of downhand butt joints and horizontal-vertical fillets, only the test detailed in 3.2 and 3.3 are required for initial approval purposes.

3.1.2 Deep penetration electrodes will only be approved as complying with Grade 1 requirements. The suffix D.P. will be added.

3.1.3 Where a manufacturer recommends that an electrode having deep penetrating properties can also be used for downhand butt welding of thicker plates with prepared edges, the electrode will be treated as normal penetration electrode, and the full series of tests in the downhand position is to be carried out as per normal penetration electrode, together with deep penetration tests given in 3.2 and 3.3.

3.1.4 Where a manufacturer desires to demonstrate that an electrode in addition to its use as normal penetration electrode also has deep penetrating properties when used for downhand butt welding and horizontal - vertical fillet welding, the additional tests given in 3.2 and 3.3 are to be carried out.

3.1.5 Where the manufacturer prescribes a different welding current and procedure for the electrode when used as a deep penetration electrode and a normal penetration electrode, the recommended current and procedure are to be used when making the test specimens in each case.

### 3.2 Deep penetration butt weld tests

3.2.1 Two plates of thickness equal to twice the diameter of the core of the electrode plus 2 [mm] are to be butt welded together with one downhand run of welding from each side. The plates are to be not less than 100 [mm] wide and of sufficient length to allow the cutting out of the test specimens of the correct number and size as shown in Fig.3.2.1. Grade A steel is to be used for these test assemblies. The joint edges are to be prepared square and smooth and, after tacking, the gap is not to exceed 0.25 [mm].

3.2.2 The test assembly is to be welded using a 8 [mm] diameter electrode or the largest diameter size manufactured if this is less than 8 [mm].

3.2.3 After welding the test assembly is to be cut to form two transverse tensile test pieces, two bend test pieces and three Charpy V-notch test pieces as shown in Fig.3.2.1. The results of tensile and impact testing are to comply with the requirements of Table 2.3.1 for Grade 1 electrodes.

3.2.4 The discards at the end of the welded assemblies are to be not more than 35 [mm] wide. The joints of these discards are to be polished and etched and must show complete fusion and interpenetration of the welds. At each cut in the test assembly the joints are also to be examined to ensure that complete fusion has taken place.

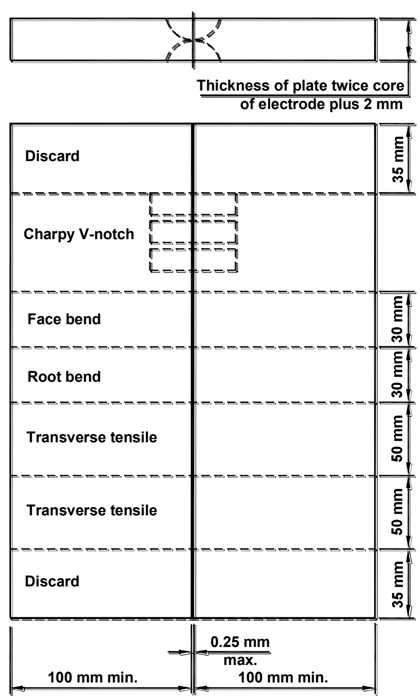



Fig. 3.2.1 : Deep penetration butt weld test assembly

### 3.3 Deep penetration fillet weld test

3.3.1 A fillet weld assembly is to be prepared as shown in Fig.3.3.1 with plates about 12.5 [mm] in thickness. The welding is to be carried out with one run for each fillet with plate A in the horizontal plane during the welding operations. The length of the fillet is to be 160 [mm] and the gap between the plates is to be not more than 0.25 [mm]. Grade A steel is to be used for these test assemblies.

3.3.2 The fillet weld on one side of the assembly is to be carried out with 4 [mm] electrode and that on the other side with the maximum size of the electrode manufactured. The welding current used is to be within the range recommended by the manufacturer and the welding is to be carried out using normal welding practice.

3.3.3 The welded assembly is to be cut by sawing or machining within 35 [mm] of the ends of the fillet welds and the joints are to be polished and etched. The welding of the fillet made with a 4 [mm] electrode is to show a penetration of 4 [mm] (See Fig.3.3.1) and the corresponding penetration of the fillet made with the maximum size of electrode manufactured is to be reported.

### 3.4 Electrodes designed for gravity or contact welding

3.4.1 This type of approval is available for welding only normal strength and higher tensile steels with minimum specified yield strengths up to 345 [N/mm$^2$].

3.4.2 Where an electrode is submitted solely for approval for use in contact welding using automatic gravity or similar welding devices, deposited metal tests, and where appropriate, fillet weld tests similar to those for normal manual electrodes are to be carried out using the process for which the electrode is recommended by the manufacturer.

3.4.3 Where an electrode is submitted for approval for use in contact welding using automatic gravity or similar welding devices in addition to normal manual welding, butt weld and, where appropriate, fillet weld tests, using gravity or other contact device as recommended by the manufacturer, are to be carried out in addition to the normal approval tests.

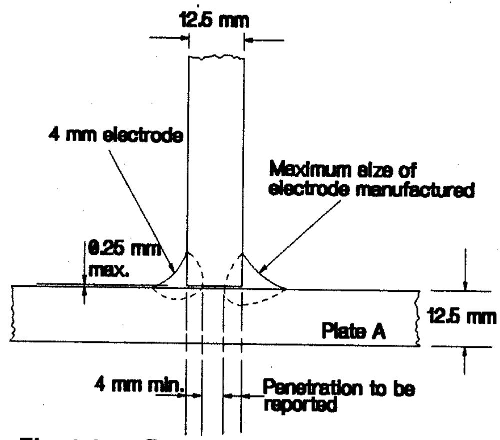



**Fig. 3.3.1 : Deep penetration fillet weld test assembly**

### 3.5 Annual tests

3.5.1 Where an electrode is approved only for deep penetration welding, the annual test is to consist of one butt welded test assembly in accordance with 3.2.

3.5.2 Where an electrode is approved for both normal and deep penetration welding, annual tests are to consist of following:-

(a) Two deposited metal test assemblies in accordance with 2.2; and

(b) One butt welded test assembly in accordance with 3.2.

3.5.3 Where an electrode is approved solely for gravity or contact welding, the annual test is to consist of one deposited metal test assembly using the gravity or other contact device as recommended by the manufacturer.

### 3.6 Certification

3.6.1 Each carton or package of approved electrodes is to contain a certificate from the manufacturer generally in accordance with 2.9.

## Section 4

## Wire-flux Combinations for Submerged Arc Automatic Welding

### 4.1 General

4.1.1 Wire-flux combinations for single electrode submerged-arc automatic or semi-automatic welding are divided into following two categories:-

(a) For use with multi-run technique;

(b) For use with two-run technique.

Where wire-flux combinations are suitable for welding with both the techniques, tests are to be carried out for each technique.

Wire-flux combinations for multiple electrode submerged arc welding will be subject to separate approval tests. They are to be carried out generally in accordance with the requirements of this section.

4.1.2 Dependent on the results of impact tests, wire-flux combinations are divided into the following grades:-

For normal strength steel - Grades 1, 2 or 3;

For higher strength steel with minimum yield strength upto 355 [N/mm$^2$] - Grades 1Y, 2Y, 3Y or 4Y.

For higher strength steels with minimum yield strength upto 390 [N/mm$^2$] - Grades 2Y40, 3Y40, 4Y40 or 5Y40.

4.1.3 The suffixes T, M or TM will be added to the grade mark to indicate two-run technique, multi-run technique or both techniques respectively.

4.1.4 The welding current may be either a.c. or d.c. (electrode positive or negative) according to the recommendation of the manufacturer. If both a.c. and d.c. are recommended, a.c. is to be used for the tests.

**4.2 Multi-run technique**

4.2.1 When approval for use with multi-run technique is required, deposited metal and butt weld tests are to be carried out in accordance with 4.3 and 4.4 respectively.

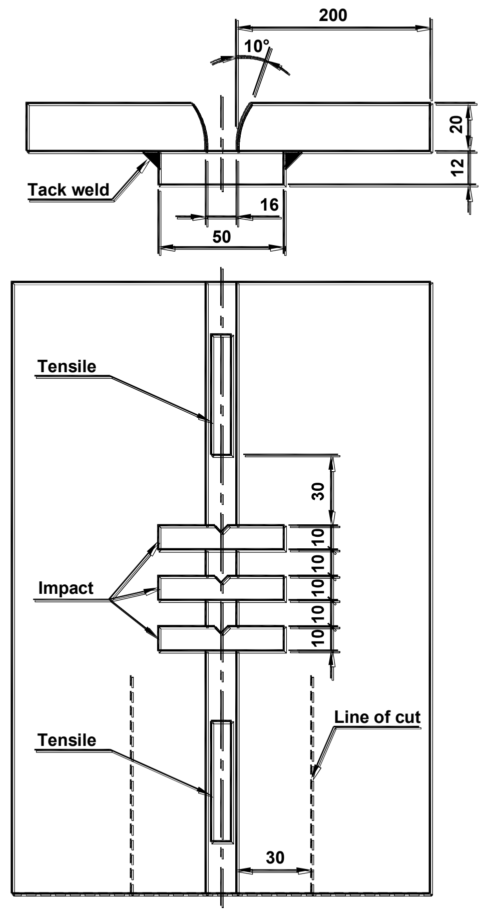
**4.3 Deposited metal tests**

4.3.1 An all weld metal test assembly is to be prepared in the downhand position as shown in Fig.4.3.1, using any grade of hull structural steel.

4.3.2 The bevelling of the plate edges is to be carried out by machining or mechanized gas cutting. In the latter case any remaining scale is to be removed from the bevelled edges.

4.3.3 The direction of deposition of each run is to alternate from each end of the plate and after completion of each run the flux and welding slag is to be removed. Between each run the assembly is to be left in still air until it has cooled to 250°C but not below 100°C, the temperature being taken in the centre of the weld, on the surface of the seam. The thickness of the layer is to be not less than the diameter of the wire but not less than 4 [mm].

4.3.4 The welding conditions (amperage, voltage and rate of travel) are to be in accordance with the recommendations of the manufacturer and are to conform with normal good welding practice for multi-run welding.




All dimensions in mm unless otherwise indicated

**Fig. 4.3.1 : Deposited metal test assembly**

4.3.5 The welded assembly is to be cut longitudinally at a distance of 30 [mm] from the edges of the weld and then cut transversely.

4.3.6 Two longitudinal tensile and three impact test specimens are to be taken from each test assembly as shown in Fig.4.3.1. Care is to be taken that the axes of the tensile test specimens coincide with the centre of the weld and the midthickness of the plates. The impact test specimens are to be cut perpendicular to the weld with their axes 10 [mm] from the upper surface. The notch is to be positioned in the centre of the weld and cut in the face of the test specimen perpendicular to the surface of the plate.

4.3.7 The results of all tests are to comply with requirements of Table 4.3.1 as appropriate. The chemical analysis of the deposited weld metal including the content of the significant alloying elements is to be submitted by the manufacturer.

**Table 4.3.1 : Requirements for deposited metal tests (wire-flux combinations)**

| Grade | Yield stress [N/mm²] | Tensile strength [N/mm²] | Elongation on 50 mm gauge length % min. | Charpy V-notch impact: Test temp. °C | Charpy V-notch impact: Avg. energy - J min. |
|---|---|---|---|---|---|
| 1 | 305 | 400 - 560 | 22 | 20 | 34 |
| 2 | | | | 0 | |
| 3 | | | | -20 | |
| 1Y | 375 | 490 - 660 | 22 | 20 | 34 |
| 2Y | | | | 0 | |
| 3Y | | | | -20 | |
| 4Y | | | | -40 | |
| 2Y40 | 400 | 510 - 690 | 22 | 0 | 39 |
| 3Y40 | | | | -20 | |
| 4Y40 | | | | -40 | |
| 5Y40 | | | | -60 | |

### 4.4 Butt weld test (two-run technique)

4.4.1 Two welded assemblies for each grade of wire-flux combination are to be prepared in accordance with Fig.4.4.1, using the following plate thicknesses:-

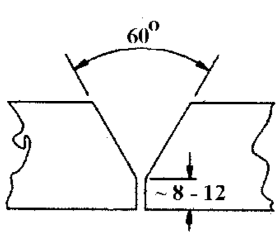
| | |
|---|---|
| For Grades 1 and 1Y | 12 to 15 [mm] and 20 to 25 [mm] |
| For Grades 2, 2Y, 3, 3Y and 4Y | 20 to 25 [mm] and 30 to 35 [mm] |
| For Grades 2Y40, 3Y40, 4Y40 and 5Y40 | 20 to 25 [mm] and 30 to 35 [mm] |

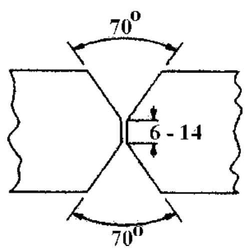
A limitation of the approval to the medium range (upto the maximum welded plate thickness) may be agreed in which case the test assemblies are to be welded using plates of 12 to 15 [mm] and 20 to 25 [mm] irrespective of the grade for which the approval is requested.

Where approval is requested for welding of both normal strength and higher tensile steel, two assemblies are to be prepared using higher tensile steel.

4.4.2 The maximum diameter of wire, grades of steel plate and edge preparation to be used are to be in accordance with Table 4.4.2. Small deviations in the edge preparation may be allowed if requested by the manufacturer. The bevelling of the plate edges is to be performed by machining or mechanized gas cutting. In the latter case any remaining scale is to be removed from the bevelled edges. The root gap should not exceed 1.0 [mm].

**Table 4.4.2 : Butt weld test assemblies (two-run technique)**

| Plate thick-ness [mm] | Recommended preparation [mm] | Max. diameter of wire [mm] | Grade of wire-flux combi-nation | Grade of normal strength steel | Grade of higher strength steel |
|---|---|---|---|---|---|
| About 12 -15 |  | 5 | 1 | A | - |
| | | | 1Y | - | AH32<br>AH36 |
| About 20 - 25 |  | 6 | 1 | A | - |
| | | | 1Y | - | AH32, AH36 |
| | | | 2 | A,B or D | - |
| | | | 2Y | - | AH32, AH36, DH32, DH36 |
| | | | 2Y40 | - | AH40, DH40 |
| | | | 3 | A,B,D or E | - |

| | | | | | |
|---|---|---|---|---|---|
| | | | 3Y | - | AH32, AH36, DH32 DH36, EH32, EH36 |
| | | | 3Y40 | - | AH40, DH40, EH40 |
| | | | 4Y | - | AH32, AH36, DH32, DH36 EH32, EH36, FH32, FH36 |
| | | | 4Y40 | - | AH40, DH40, EH40, FH40 |
| | | | 5Y40 | - | AH40, DH40, EH40, FH40 |
| About 30 - 35 |   | 7 | 2 | A, B or D | - |
| | | | 2Y | - | AH32, AH36, DH32, DH36 |
| | | | 2Y40 | - | AH40, DH40 |
| | | | 3 | A, B, D or E | - |
| | | | 3Y | - | H32, AH36, DH32, DH36, EH32, EH36 |
| | | | 3Y40 | - | AH40, DH40, EH40 |
| | | | 4Y | - | AH32, AH36, DH32, DH36, EH32, EH36, FH32, FH36 |
| | | | 4Y40 | - | AH40, DH40, EH40, FH40 |
| | | | 5Y40 | - | AH40, DH40, EH40, FH40 |

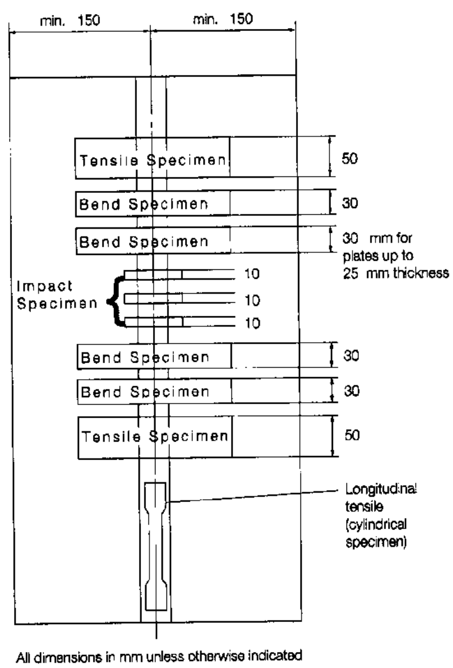



**Fig.4.4.1 : Butt weld test assembly (two-run technique)**

4.4.3 The welding current may be either a.c. or d.c. (electrode positive or negative) according to the recommendation of the manufacturer. If both a.c. and d.c. are recommended a.c. is to be used for test pieces.

4.4.4 Each butt weld is to be welded in two runs, one from each side, using amperages, voltages and travel speeds in accordance with the recommendations of the manufacturer and normal good welding practice.

4.4.5 After completion of the first run, the flux and welding slag are to be removed and the assembly is to be left in still air until it has cooled to 100°C, the temperature being taken in the centre of the weld, on the surface of the seam. After being welded the test assemblies are not to be subjected to any heat treatment.

4.4.6 It is recommended that welded assemblies be subjected to radiographic examination to ascertain any defects in the weld prior to testing.

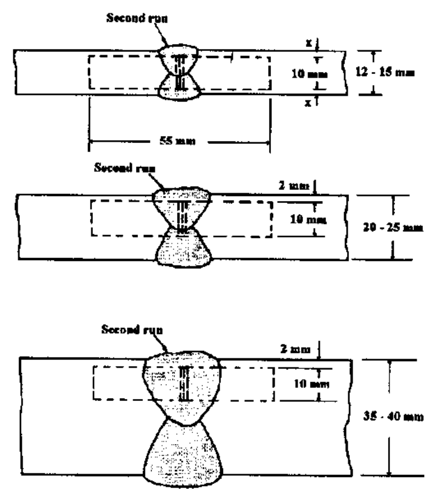



**Fig. 4.4.3 : Butt weld test assemblies - two-run technique : position of impact test specimens**

4.4.7 The assemblies are to be cut transversely, to form two tensile test pieces and two bend test pieces as shown in Fig.4.4.1, three impact test pieces as shown in Fig.4.4.1 and Fig.4.4.3. The edges of all test pieces and also the discards are to be examined to ensure complete fusion and interpenetration of welds.

4.4.8 Where the wire-flux combination is to be used for two-run technique only, a longitudinal test is also to be made in accordance with Fig.4.5.1 on the thicker plate tested.

4.4.9 The results of the transverse tensile and impact tests are to comply with the requirements of Table 4.5.1 as appropriate. The results of longitudinal tensile test are to comply with the requirements of Table 4.3.1 as appropriate except that for Grades 1Y, 2Y and 3Y the tensile strength is not to be less than 490 [N/mm$^2$].

**4.5 Butt weld test (multi-run technique)**

4.5.1 A butt weld assembly, as shown in Fig.4.5.1, is to be prepared in the downhand position by welding together two 20 [mm] thick plates of not less than 150 [mm] in width and of sufficient length to allow the cutting out of test specimens of the prescribed number and size.

4.5.2 The grade of steel used for the preparation of the test assembly is to be as follows:-

| | |
|---|---|
| Grade 1 wire-flux combination | Grade A |
| Grade 2 wire-flux combinations | Grade A, B, D |
| Grade 3 wire-flux combinations | Grade A, B, D, E |
| Grade 1Y wire-flux combinations | Grade AH32, AH36 |
| Grade 2Y wire-flux combinations | AH32, AH36, DH32, DH36 |
| Grade 3Y wire-flux combinations | AH32, AH36, DH32, DH36, EH32, EH36 |
| Grade 4Y wire-flux combinations | AH32, AH36, DH32, DH36, EH32, EH36, FH32, FH36 |
| Grade 2Y40 wire-flux combinations | AH40, DH40 |
| Grade 3Y40 wire-flux combinations | AH40, DH40, EH40 |
| Grade 4Y40 wire-flux combinations | AH40, DH40, EH40, FH40 |
| Grade 5Y40 wire-flux combinations | AH40, DH40, EH40, FH40 |

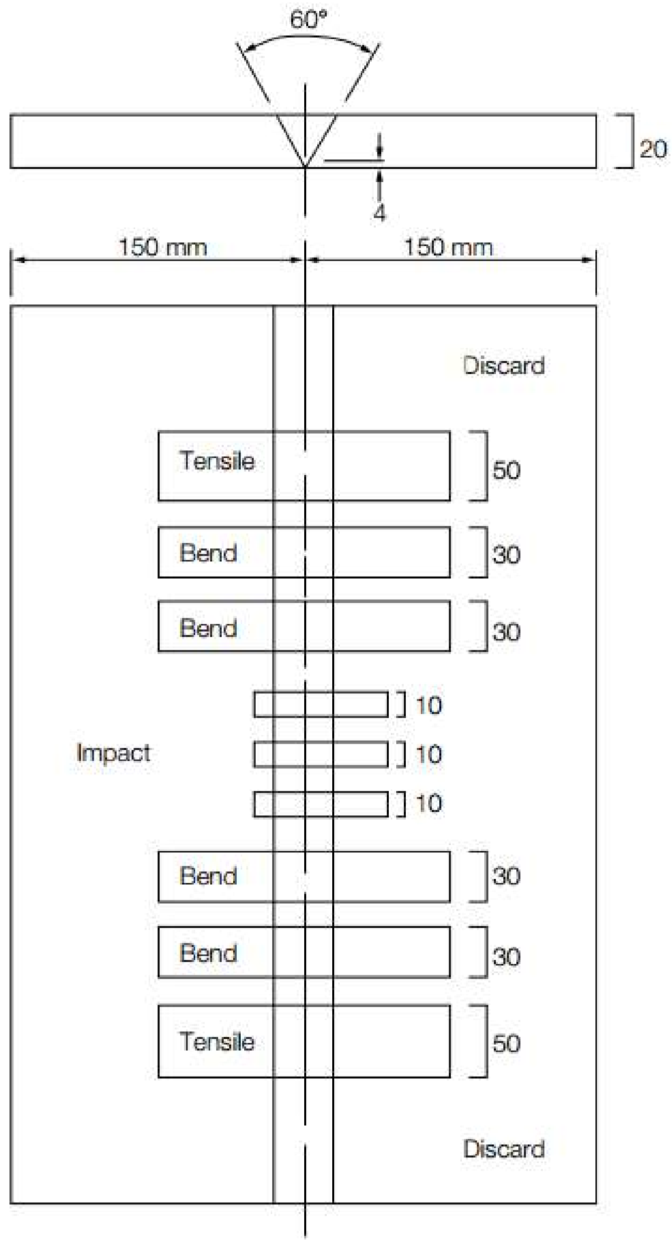



**Fig 4.5.1 Multi-run butt weld test assembly (Submerged arc welding)**

4.5.3 Welding is to be carried out in the downhand position, and the direction of deposition of each run is to alternate from each end of the plate. After completion of each run, the flux and welding slag is to be removed. Between each run the assembly is to be left in still air until it has cooled to less than 250°C but not below 100°C, the temperature being taken in the centre of the weld, on the surface of the seam. The thickness of the layer is to be not less than the diameter of the wire nor less than 4 [mm].

4.5.4 The plate edges are to be prepared to form a single vee joint, the included angle between the fusion faces being 60 degrees and the root face being 4 [mm]. The bevelling of the plate edges is to be carried out by machining or mechanized gas cutting. In the latter case, any remaining scale is to be removed from the bevelled edges.

4.5.5 The welding is to be carried out by the multi-run technique and the welding conditions are to be the same as those adopted for the deposited metal test assembly.

4.5.6 The back sealing run is to be applied in the downhand position after cutting out the root run to clean metal. After being welded the test assembly is not to be subjected to any heat treatment.

4.5.7 It is recommended that the welded assembly be subjected to radiographic examination to ascertain any defects in the weld prior to testing.

4.5.8 The test assembly is to be cut to form two tensile; two face bend; two root bend; three impact test pieces as shown in Fig.4.5.1.

4.5.9 The results of all tensile and impact test specimens are to comply with the requirements of Table 4.5.1 as appropriate. The position of the fracture of the transverse tensile test is to be reported.

**Table 4.5.1 : Requirements for butt weld tests (wire flux-combination)**

| Grade | Tensile strength (transverse test) [N/mm$^2$] min. | Charpy V-notch impact test | |
|---|---|---|---|
| | | Test temp. °C | Avg. energy J min. (See note) |
| 1<br>2<br>3 | 400 | 20<br>0<br>-20 | 34 |
| 1Y<br>2Y<br>3Y<br>4Y | 490 | 20<br>0<br>-20<br>-40 | 34 |
| 2Y40<br>3Y40<br>4Y40<br>5Y40 | 510 | 0<br>-20<br>-40<br>-60 | 39 |
| Note : No individual impact test value is to be less than 23J | | | |

**4.6 Annual tests**

4.6.1 Following tests on wire-flux combinations are to be carried out at the time of annual inspection:-

**(a)** For two-run technique :- On butt weld assembly with 20 [mm] minimum plate thickness : One transverse tensile, two transverse bends and three impact tests. One longitudinal tensile test specimen is also to be prepared where the wire-flux combination is approved solely for the two-run technique.

**(b)** For multi-run technique :- Deposited metal Tests - One tensile and three impact tests in accordance with 4.3.

4.6.2 The specimens are to be prepared and tested in accordance with, and on grades of steel specified for initial approval tests and the results are to comply with the results of the approved grade.

**4.7 Upgrading and uprating**

4.7.1 Requests for upgrading and uprating will generally be considered at the time of annual testing and additional tests in accordance with the requirements of 2.8 would be required.

## Section 5

## Wires and Wire-gas Combinations for Semi-automatic and Automatic Welding

**5.1 General**

5.1.1 Wire-gas combinations and flux-cored or flux-coated wires (for use with or without a shielding gas) are divided into following categories for the purposes of approval testing:-

(a) For use in semi-automatic multi-run welding;

(b) For use in single electrode multi-run automatic welding; and

(c) For use in single electrode two-run automatic welding.

5.1.2 The term 'semi-automatic' is used to describe processes in which the weld is made manually by a welder holding a gun through which the wire is continuously fed. A suffix S will be added after the grade mark to indicate approval for semi-automatic multi-run welding.

5.1.3 Dependent on the results of impact tests, wires and wire-gas combinations are divided into the following grades:-

| | |
|---|---|
| For normal strength steel | Grades 1, 2 and 3 |
| For higher strength steel with minimum yield strength upto 355 [N/mm$^2$] | Grades 1Y, 2Y, 3Y and 4Y. |
| For higher strength steels with minimum yield strength upto 390 [N/mm$^2$] | Grades 2Y40, 3Y40, 4Y40 and 5Y40 |

5.1.4 For wires intended for automatic welding, the suffixes T, M or TM will be added after the grade mark to indicate approval for two-run, multi- run or both welding techniques, respectively.

5.1.5 For wires intended for both semi-automatic and automatic welding, the suffixes will be added in combination.

5.1.6 Where applicable, the composition of the shielding gas is to be reported. Unless otherwise agreed, additional approval tests are required when the shielding gas is different from that used for the original approval tests.

Where a wire in combination with any particular gas has been approved, usage of the same wire with another gas in the same group as defined in Table 5.1.6 may be considered.

5.1.7 Flux-cored or flux-coated wires which have satisfied the requirements for Grades 2, 2Y, 2Y40, 3, 3Y, 3Y40, 4Y, 4Y40 and 5Y40 may, at the option of the manufacturer, be submitted to the hydrogen test as detailed in 2.5 using the manufacturer's recommended welding condi-tions and adjusting the deposition rate to give a weight of weld deposit per sample similar to that deposited when using manual electrodes. A suffix H15, H10 or H5 will be added to the grade mark, in the same conditions as for manual arc welding electrodes to indicate compliance with the requirements of the test.

**Table 5.1.6 : Compositional limits of designated groups of gas types and mixtures**

| Group | | Gas Composition (Vol. %) | | | |
|---|---|---|---|---|---|
| | | $CO_2$ | $O_2$ | $H_2$ | Ar |
| M1 | 1 | > 0 to 5 | - | > 0 to 5 | Rest 1) 2) |
| | 2 | > 0 to 5 | - | - | |
| | 3 | - | > 0 to 3 | - | |
| | 4 | > 0 to 5 | > 0 to 3 | - | |
| M1 | 1 | > 5 to 25 | - | - | Rest 1) 2) |
| | 2 | - | 3 to 10 | - | |
| | 3 | > 5 to 25 | > 0 to 3 | - | |
| M1 | 1 | > 25 to 50 | - | - | Rest 1) 2) |
| | 2 | - | > 10 to 15 | - | |
| | 3 | > 5 to 50 | > 8 to 15 | - | |
| C | 1 | 100 | - | - | Rest 1) 2) |
| | 2 | Rest | > 0 to 30 | - | |

1) Argon may be substituted by Helium upto 95% of the Argon content.

2) Approval covers gas mixtures with equal or higher Helium contents only.

### 5.2 Approval tests for two-run automatic welding

5.2.1 Approval tests for two-run automatic welding are to be carried out generally in accordance with the requirements of Sec.4 using the two-run automatic welding technique for the preparation of all test assemblies.

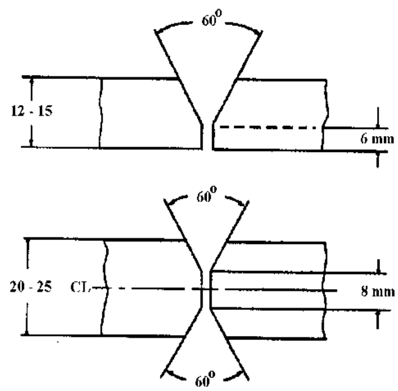



**Fig.5.2.1 : Recommended edge preparation for two-run butt weld test assemblies**

5.2.2 Two butt weld test assemblies are to be prepared generally as detailed in 4.4.1 and 4.4.2 using plates 12-15 [mm] and 20-25 [mm] in thickness.

5.2.3 If approval is requested for welding plates thicker than 25 [mm], one assembly is to be prepared using plates approximately 20 [mm] in thickness and the other using plates of maximum thickness for which approval is requested.

5.2.4 The edge preparation of test assemblies is to be as shown in Fig.5.2.1. Small deviations in the edge preparation may be allowed, if requested by the manufacturer. For assemblies using plates over 25 [mm] in thickness, the edge preparation is to be reported for information.

### 5.3 Approval tests for semi-automatic multi-run welding

5.3.1 Approval tests for semi-automatic multi-run welding are to be carried out generally in accordance with the requirements of Sec.2, using the semi-automatic multi-run technique for the preparation of all test assemblies.

5.3.2 Two deposited metal test assemblies are to be prepared in the downhand position as shown in Fig.2.2.1, one using the smallest diameter, and the other using the largest diameter of the wire intended for the welding of ship structures. The weld metal is to be deposited according to the practice recommended by the manufacturer, and the thickness of each layer of weld metal is to be between 2 [mm] and 6 [mm]. Where only one diameter is manufactured, only one deposited metal assembly is to be prepared.

5.3.3 Butt weld assemblies as shown in Fig.2.3.1 are to be prepared for each welding position (downhand, horizontal-vertical, vertical-upwards, vertical-downwards and overhead) for which the wire is recommended by the manufacturer.

5.3.4 The downhand assembly is to be welded using, for the first run, wire of 1.2 [mm] diameter or of the smallest diameter manufactured and, for the remaining runs, wire of 2.4 [mm] diameter or the largest diameter manufactured.

5.3.5 Where approval is requested only in the downhand position, an additional butt weld assembly is to be prepared in that position using wires of different diameter from those required by 5.3.4.

5.3.6 The butt weld assemblies, in positions other than downhand, are to be welded using for the first run, wire of 1.2 [mm] diameter or of the smallest diameter manufactured, and for the remaining runs, the largest diameter of wire recommended by the manufacturer for the position concerned.

5.3.7 Fillet weld test in accordance with Sec.2 is to be carried out.

### 5.4 Approval tests for multi-run automatic welding

5.4.1 Approval tests for multi-run automatic welding are to be carried out generally in accordance with the requirements of Sec.4 using the multi-run automatic welding technique for the preparation of all test assemblies.

5.4.2 One deposited metal test assembly is to be prepared as shown in Fig.4.3.1. Welding is to be as detailed in Sec.4 except that thickness of each layer is to be not less than 3 [mm].

5.4.3 A butt weld assembly is to be prepared, as shown in Fig.4.5.1.

### 5.5 Annual tests

5.5.1 The annual tests are to consist of at least the following:-

**(a)** Wires approved for semi-automatic or for both semi-automatic and automatic multi-run welding: One deposited metal test assembly prepared in accordance with 5.3 using a wire of diameter within the range intended for the welding of the ship structures;

**(b)** Wires approved for automatic multi-run welding: One deposited metal test assembly prepared in accordance with 5.4 using a wire of diameter within the range intended for the welding of the ship structure;

**(c)** Wires approved for two-run automatic welding: One butt weld test assembly prepared in accordance with 5.2 using plates 20 to 25 [mm]

in thickness. The diameter of the wire used is to be reported.

5.5.2 From the test assemblies prepared in accordance with 5.5.1, only the following tests are to be carried out:-

**(a)** For deposited metal assemblies: One tensile and three impact tests;

**(b)** For butt weld assemblies: One transverse tensile, two bend and three impact tests. One longitudinal tensile test is also required where the wire is approved solely for two-run automatic welding.

**5.6 Upgrading and uprating**

5.6.1 Requests for upgrading and uprating will generally be considered at the time of annual testing and additional tests in accordance with the requirements of 2.8 would be required.

## Section 6

## Consumables for use in Electro-slag and Electro-gas Vertical Welding

**6.1 General**

6.1.1 The requirements for the two-run technique as detailed in Sec.4 are applicable for the approval of special consumable used in electro-slag and electro-gas vertical welding with or without consumable nozzles except as otherwise required by the following requirements especially as regards the number and kind of the test-pieces used for the mechanical tests and taken from the butt welded assemblies.

6.1.2 For Grades 1Y, 2Y, 3Y, 4Y, 2Y40, 3Y40, 4Y40 and 5Y40 approval of the consumables may be restricted for use only with specific types of higher tensile steel. This is in respect of the content of grain refining elements, and if general approval is required, a niobium treated steel is to be used for the approval tests.

6.1.3 For these special welding consumables, the requirements of 1.3 may not be entirely applicable for technical reasons.

Where approval is requested for welding of both normal strength and higher tensile steel two assemblies are to be prepared using higher tensile steel. Two assemblies prepared using normal strength steel may also be required at the discretion of Designated Authority/Classification Society.

**6.2 Butt weld tests**

6.2.1 Preparation of test assemblies

- Two butt weld test assemblies are to be prepared, one of them with plates 20/25 [mm] thick, the other with plates 35/40 [mm] thick or more. The grade of the steel to be used for each one of these assemblies must be selected according to the requirements given in the Table 4.4.2.
- The chemical composition of the plate, including the content of grain refining elements is to be reported.
- The welding conditions and the edges preparation are to be those recommended by the welding consumable manufacturer and are to be reported.

6.2.2 Radiographic examination

It is recommended that the welded assemblies be subjected to a radiographic examination to ascertain if there are any defects in the weld prior to the preparation of test specimens.

6.2.3 Test series

- Each assembly shall be cut to give test specimens according to Fig.6.2.1.

The length of the assembly should be sufficient to allow the selection of all the following test specimens:

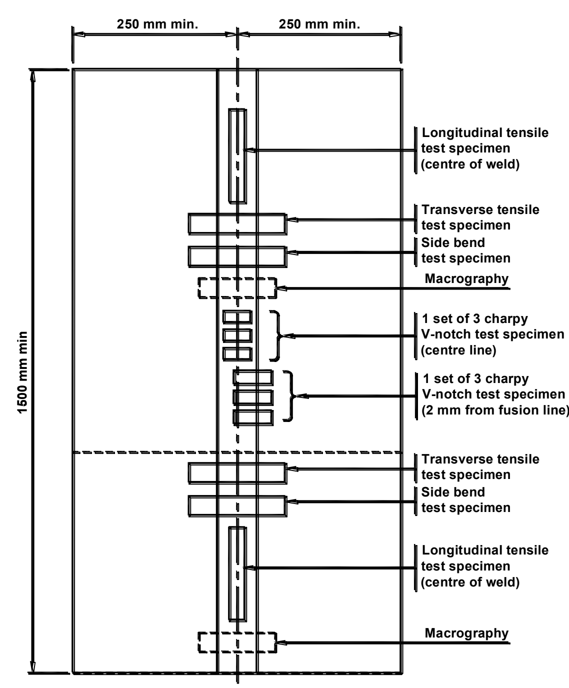



Fig. 6.2.1 : Butt weld test assembly

- 2 longitudinal tensile test specimens with their axis at the centre of the weld;

- 2 transverse tensile test specimens;
- 2 side bend test specimens;
- 2 sets of 3 Charpy-V notch impact test specimens in accordance with Fig.6.2.1 comprising of :
- 1 set with the notch in the axes of the weld;
- 1 set with the notch at 2 [mm] from the fusion line in the deposited metal; and
- 2 macro-sections of the weld (towards the middle of the weld and towards one end).

6.2.4 Results to be obtained

The results of the tensile, bend and impact tests are to comply with the requirements of 4.4 (two-run welding) for the class of filler product in question.

**6.3 Annual tests**

6.3.1 One test assembly must be prepared from plates 20/25 [mm] thick, and tested as indicated in 6.2.

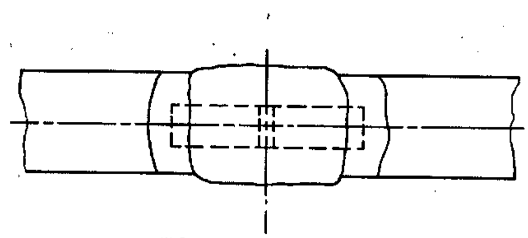
The following specimens are to be selected :

- 1 longitudinal tensile specimen from the axis of the weld:
- 1 transverse tensile specimen;
- 2 side bend specimens;
- 3 Charpy-V specimens notched at the centre of the weld (position 1 Fig.6.3.1);
- 3 Charpy-V specimens cut out transverse to the weld with their notches at 2 [mm] from the fusion line, in the weld; and
- macro section.

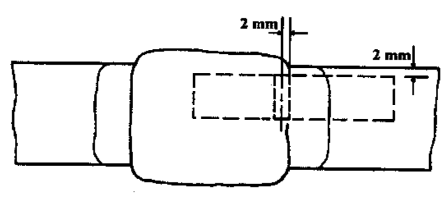
6.3.2 The results to be obtained should meet the requirements given in 4.4 (two-run welding) for the class of the consumables in question.

**6.4 Upgrading and uprating**

6.4.1 Upgrading and uprating will be considered only at the manufacturers request, preferably at the time of annual testing. Generally, for this purpose, full tests from butt weld assemblies as indicated in 6.2 will be required, irrespective of the other tests requested if the concerned consumable is also approved (and possibly upgraded or uprated) according to Sec.4 or Sec.5.



(1) In the centre of the weld metal




(2) In the weld metal, 2 mm from the fusion line

**Fig.6.3.1 : Position of Charpy V-notch impact test specimens**

## Section 7

## Welding Consumables for High Strength Steels for Welded Structures

### 7.1 General

#### 7.1.1 Scope

7.1.1.1 These requirements supplement the requirements of Sections 1 to 6 and give the conditions of approval and inspection of welding consumables used for high strength steels for welded structures according to Ch.3, Sec.4 with yield strength levels from 420 [N/mm$^2$] upto 960 [N/mm$^2$] and impact grades AH, DH, EH and FH, except impact grade FH is not applicable for 890 [N/mm$^2$] and 960 [N/mm$^2$] yield strength levels.

Where no special requirements are given, those of Sections 1 to 6 apply in analogous manner.

7.1.1.2 The welding consumables preferably to be used for the steels concerned are divided into several categories as follows:

- covered electrodes for manual welding,
- wire-flux combinations for multirun sub-merged arc welding,
- solid wire-gas combinations for arc welding (including rods for gas tungsten arc welding),
- flux cored wire with or without gas for arc welding.

#### 7.1.2 Grading, Designation

7.1.2.1 Based on the yield strength of the weld metal, the welding consumables concerned are divided into eight (yield) strength groups:

Y42 for welding steels with minimum yield strength 420 [N/mm$^2$]

Y46 for welding steels with minimum yield strength 460 [N/mm$^2$]

Y50 for welding steels with minimum yield strength 500 [N/mm$^2$]

Y55 for welding steels with minimum yield strength 550 [N/mm$^2$]

Y62 for welding steels with minimum yield strength 620 [N/mm$^2$]

Y69 for welding steels with minimum yield strength 690 [N/mm$^2$]

Y89 for welding steels with minimum yield strength 890 [N/mm$^2$]

Y96 for welding steels with minimum yield strength 960 [N/mm$^2$].

Wire-flux combinations for single or two-run technique are subject to special consideration of Designated Authority/Classification Society.

7.1.2.2 Each of the eight (yield) strength groups is further divided into three main grades in respect of charpy V-notch impact test requirements (test temperatures):

| Grade | Test temperature |
|---|---|
| 3 | - 20°C |
| 4 | - 40°C |
| 5 | - 60°C |

7.1.2.3 Analogously to the designation scheme used in Section 1 to 6 the welding consumables for high strength steels are subject to additional designation and approval as follows:

- According to 7.1.2.2 with the quality grades 3, 4 or 5.
- With the added symbol Y and an appended code number designating the minimum yield strength of the weld metal corresponding to 7.1.2.1 : Y42, Y46, Y50, Y55, Y62, Y69, Y89 and Y96.
- With the added symbol H10 or H5 for controlled hydrogen content of the weld metal.
- With the added symbol S (= semi-automatic) for semi-mechanised welding.
- With the added symbol M designating multirun technique and is applicable only to welding consumables for fully mechanised welding).

7.1.2.4 Each higher quality grade includes the one (or those) below, AH, DH steels according to Ch.3, Sec.4 are to be welded using welding consumables of at least quality grade, 3, grade EH steels using at least quality grade 4 and grade FH steels using at least quality grade 5, as per the following table:

| Consumables Grade | Steel Grades covered |
|---|---|
| 3Y.. | DH.. |
| 4Y.. | EH..and FH.. |
| 5Y.. | FH.., EH.. and DH.. |

7.1.2.5 Welding consumables approved with grades.Y42, ..Y46 and ..Y50 are also considered suitable for welding steels in the two strength levels below that for which they have been approved. Welding consumables approved with grades ..Y55, ..Y62 and ..Y69 are also considered suitable for welding steels in the one strength level below that for which they have been approved. Welding consumables with grade Y89 are considered suitable for welding steels in the same strength level only. Welding consumables with grade Y96 are also

considered suitable for welding steels in the one strength level below that for which they have been approved. For grade Y89 and Y96, where the design requirements permit undermatching weld joint, then welding consumables within the scope of this section can be considered subject to Designated Authority/Classification Society's discretion and Manufacturer's recommendations.

7.1.2.6 Designated Authority/Classification Society may, in individual cases, restrict the range of application in (up to) such a way, that approval for any one strength level does not justify approval for any other strength level.

**7.1.3 Manufacture, testing and approval procedure**

7.1.3.1 Manufacturer's plant, production methods and quality control measures shall be such as to ensure reasonable uniformity in manufacture, see also Sec.1.

7.1.3.2 Testing and approval procedure shall be in accordance with Sec.1 and as required in Section 1 to 6 for the individual categories (types) of welding consumables mentioned in 7.1.1.2 above.

**7.2 Testing of the weld metal**

7.2.1 For testing the deposited weld metal, test pieces analogous to those called for in Sections 1 to 6 respectively shall be prepared, depending on the type of the welding consumables (and according to the welding process). The base metal used shall be a fine-gained structural steel

compatible with the properties of the weld metal, or the side walls of the weld shall be buttered with a weld metal of the same composition.

7.2.2 The chemical composition of the deposited weld metal shall be determined and certified in a manner analogous to that prescribed in Sec.2, Cl.2.2.4. The results of the analysis shall not exceed the limit values specified in the standards or by the manufacturer, the narrower tolerances being applicable in each case.

7.2.3 Depending on the type of the welding consumables (and according to the welding process), the test specimens prescribed in Sections 1 to 6 respectively shall be taken from the weld metal test pieces in a similar manner.

7.2.4 The mechanical properties must meet the requirements stated in Table 7.2.1 and Table 7.2.2. The provisions of Sections 1 to 6 apply in analogous manner to the performance of the tests, including in particular the maintenance of the test temperature in the notched bar impact test and the carrying out of results.

7.2.5 Specifications of welding consumables used for welding high strength extremely thick steel plates of thickness more than 50 [mm] but not exceeding 100[mm] of EH47 grade used in container carriers are to be in accordance with Table 7.2.3

7.2.6 Welding consumables for brittle crack arrest steels are to be in accordance with the relevant requirements for each steel grade excluding suffix "BCA1" or "BCA2" specified in Table 10.1.3 of Chapter 3, Section 10.

**7.3 Testing on welded joints**

7.3.1 Depending on the type of the welding consumables (and according to the welding process), the testing on the welded joints shall be performed on butt-weld test pieces in a manner analogous to that called for in Sections 1 to 6.

7.3.2 Depending on the type of the welding consumables (and according to the welding process), the butt-weld test pieces called for in para 7.3.1 shall be welded in a manner analogous to that prescribed in Sections 1 to 6. The base metal used shall be a high-strength fine-grained structural steel with a minimum yield strength and tensile strength matching the consumable grade being approved and compatible with the added symbol for which application is made.

7.3.3 Depending on the type of the welding consumables (and according to the welding process), the test specimens described in Sections 1 to 6 shall be taken from the butt-weld test pieces.

7.3.4 The mechanical properties must meet the

requirements stated in Table 7.3.1. The provisions of Sections 1 to 6 apply in analogous manner to the performance of the tests, including in particular the maintenance of the test temperatures in the notched bar impact test and the requirements regarding the retest specimens.

**Table 7.2.1 : Required toughness properties of the weld metal**

| Quality Grade | Test temp.°C | Min. notch impact energy [J] [1)] |
|---|---|---|
| 3 | - 20 | Y42: ≥ 47<br>Y46: ≥ 47<br>Y50: ≥ 50<br>Y55: ≥ 55<br>Y62: ≥ 62 |
| 4 | - 40 | |
| 5 | - 60 | |

| | | |
|---|---|---|
| | | Y69: ≥ 69<br>Y89: ≥ 69 2)<br>Y96: ≥ 69 2) |

1) Charpy V-notch impact test specimen, mean value of three specimens; for requirements regarding minimum individual values and retests, See Section 1, 1.10
2) Quality grade 5 is not applicable for Y89 and Y96 grade consumables.

**Table 7.2.2 : Required strength properties of the weld metal**

| **Symbols added to quality grade** | **Min. yield strength or 0.2% proof stress [N/mm$^2$]** | **Tensile Strength [N/mm$^2$]** | **Minimum elongation [%]** |
|---|---|---|---|
| Y42 | 420 | 520 - 680 | 20 |
| Y46 | 460 | 540 - 720 | 20 |
| Y50 | 500 | 590 - 770 | 18 |
| Y55 | 550 | 640 – 820 | 18 |
| Y62 | 620 | 700 - 890 | 18 |
| Y69 | 690 | 770 - 940 | 17 |
| Y89 | 890 | 940 - 1100 | 14 |
| Y96 | 960 | 980 - 1150 | 13 |

**Table 7.2.3 : Required strength properties for deposited metal used to weld high strength extremely thick steel plates of thickness more than 50[mm] but not exceeding 100[mm], of EH47 grade used in container carriers,**

| Mechanical Properties | | | Impact Test | |
|---|---|---|---|---|
| Yield Strength [N/mm$^2$] min. | Tensile Strength [N/mm$^2$] | Elongation (%) min | Test Temp. [$^o$C] | Average Impact Energy [J] min. |
| 460 | 570 - 720 | 19 | -20 | 64 |

7.3.5 Where the bending angle required in Table 7.3.1 is not achieved, the specimen may be considered as fulfilling the requirements, if the bending elongation on a gauge length Lo fulfills the minimum elongation requirements stated in Table 7.2.2. The gauge length Lo = Ls + t (Ls = width of weld, t = specimen thickness), see Fig.7.3.1.

7.3.6 Mechanical Properties for Butt weld tests for high strength extremely thick steel plates of thickness more than 50[mm] but not exceeding 100[mm], of EH47 grade used in container carriers are to be as per Table 7.3.2

| Table 7.3.1 : Required properties of welded joints | | | | | |
|---|---|---|---|---|---|
| **Quality Grade** | **Added symbol** | **Min. tensile strength [N/mm²]** | **Min. notch impact energy, test temperature** | **Minimum bending angle 1)** | **Bend ratio D/t 2)** |
| 3 to 5 in accordance with Table 7.2.1 | Y42 | 520 | Depending on the quality grade and yield strength in accordance with Table 7.2.1 | 120° | 4 |
| | Y46 | 540 | | | 4 |
| | Y50 | 590 | | | 4 |
| | Y55 | 640 | | | 5 |
| | Y62 | 700 | | | 5 |
| | Y69 | 770 | | | 5 |
| | Y89 | 940 | | | 6 |
| | Y96 | 980 | | | 7 |

1) Bending angle attained before the first incipient crack, minor pore exposures upto a maximum length of 3 mm allowed.
2) D = Mandrel diameter, t = specimen thickness

| Table 7.3.2 : Mechanical Properties for Butt weld tests for high strength extremely thick steel plates of thickness more than 50[mm] but not exceeding 100[mm], of EH47 grade used in container carriers | | | |
|---|---|---|---|
| Tensile Strength [N/mm²] | Bend Test Ratio: D/t | Charpy V-notch Impact Tests | |
| | | Test Temperature (°C) | Average Energy (J) min. |
| 570-720 | 4 | -20 | 64 |

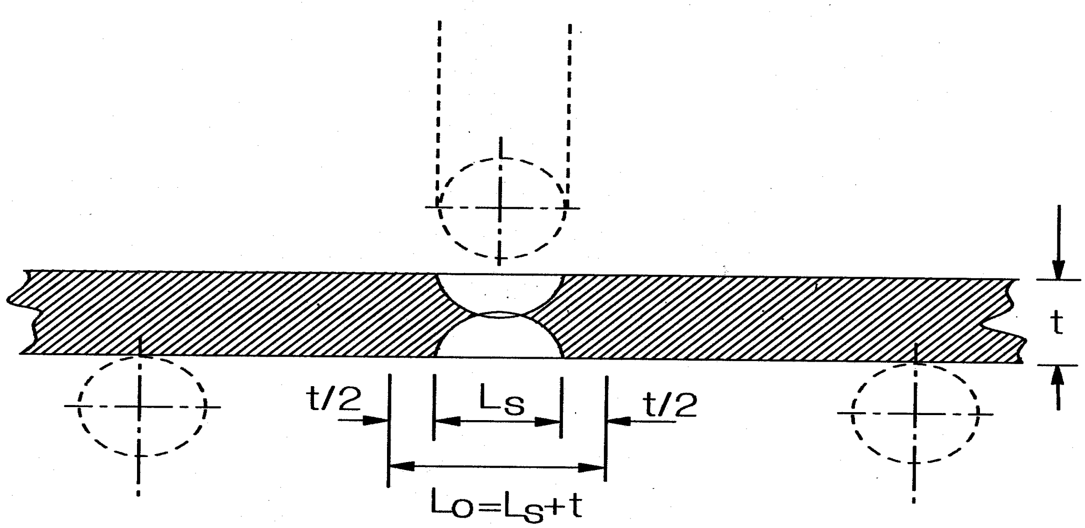



**Fig.7.3.1 : Required proportion of welded joints**

**7.4 Hydrogen test**

7.4.1 The welding consumables, other than solid wire-gas combinations, shall be subjected to a hydrogen test in accordance with the mercury method to ISO 3690:2018, or any other method such as the gas chromatographic method which correlates with that method, in respect of cooling rate and delay times during preparation of the weld samples, and the hydrogen volume determinations.

7.4.2 The diffusible hydrogen content of the weld metal determined in accordance with the provisions of Sec.2, Para 2.5 shall not exceed the limits given in Table 7.4.1.

| Table 7.4.1 : Allowable diffusible hydrogen content | | |
|---|---|---|
| **Yield strength group** | **Hydrogen symbol** | **Max. hydrogen content [$cm^3$/100 g deposited weld metal]** |
| Y42<br>Y46<br>Y50 | H 10 | 10 |
| Y55<br>Y62<br>Y69 | H 5 | 5 |
| Y89<br>Y96 | H 5 | 5 |

**7.5 Annual tests**

7.5.1 The annual repeat tests specified in Sections 1 to 6 shall entail the preparation and testing of weld metal test pieces as prescribed under 7.2. For grades Y69 to Y96 annual hydrogen test is required. In special cases,

Designated Authority/Classification Society may require more extensive tests.

## Section 8

## Consumables for Welding of Aluminium Alloys

**8.1 General**

8.1.1 Tests for the approval of consumables intended for welding the aluminium alloys detailed in Ch.9 are to be carried out generally in accordance with the requirements of Secs.1,2 and 5, except as otherwise detailed in this Section.

8.1.2 The welding consumables are divided into two categories as follows:

W = wire electrode, wire - gas combinations for metal arc inert gas welding (MIG, 131 according to ISO 4063:2009), tungsten inert gas welding (TIG, 141) or plasma arc welding (15)

R = rod - gas combinations for tungsten inert gas arc welding (TIG, 141) or plasma arc welding (15)

8.1.3 Approval will be indicated by the grade as shown in Table 8.1.3.

| Table 8.1.3 : Consumables grades and base materials for the approval test | | |
|---|---|---|
| **Consumable quality grade (Symbol)** | **Base material for the tests** | |
| | **Alloy Designation** | |
| | **Numerical** | **Chem-Symbol** |
| RA/WA | 5754 | AlMg3 |
| RB/WB | 5086 | AlMg4 |
| RC/WC | 5083<br>5383<br>5456<br>5059 | AlMg4.5 Mn0.7<br>AlMg4.5 Mn0.9<br>AlMg5<br>- |
| RD/WD | 6082<br>6005A<br>6061 | AlSi1MgMn<br>AlSiMg(A)<br>AlMg1SiCu |
| Note: Approval on higher strength AlMg base materials covers also the lower strength AlMg grades and their combination with AlSi grades | | |

8.1.4 The welding technique will be indicated in the approval grading by a letter as under:

m - manual multi-run welding (GTAW);

S - semi-automatic multi-run welding (GMAW);

M - automatic multi-run welding (GTAW or GMAW);

T - automatic two-run welding (GMAW).

8.1.5 The compositions, of the shielding gas and the filler/electrode wire are to be reported.

8.1.6 Approval of a wire or a rod will be granted in conjunction with a specific shielding gas according to Table 8.1.6 or defined in terms of composition and purity of "special" gas to be designated with group sign "S". The composition of the shielding gas is to be reported. Where a wire in combination with any particular gas has been approved, usage of the same wire with another gas in the same group as defined in Table 8.1.6 may be considered.

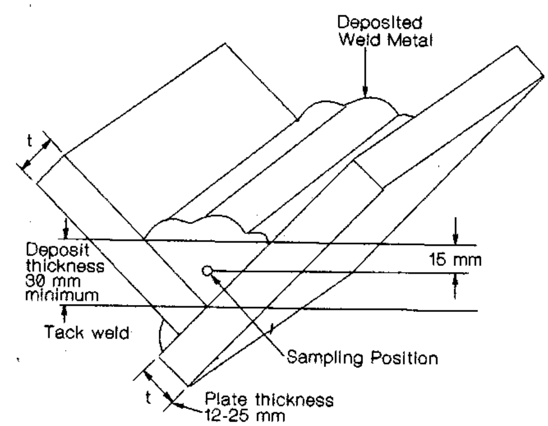



**Fig.8.3.1 : Deposited metal test assembly**

**Table 8.1.6 : Compositional limits of shielding gases and mixtures to be used**

| Group | Gas composition (Vol.%)[1] | |
|---|---|---|
| | Argon | Helium |
| I - 1 | 100 | - |
| I - 2 | - | 100 |
| I - 3 | Rest | > 0 to 33 |
| I - 4 | Rest | > 33 to 66 |
| I - 5 | Rest | > 66 to 95 |
| S | Special gas, composition to be specified, See 8.1.6 | |

1) Gases of other chemical composition (mixed gases) may be considered as "special gases" and covered by a separate test.

8.1.7 On completion of welding, assemblies must be allowed to cool naturally to ambient temperature. Welded test assemblies and test specimens must not be subjected to any heat treatment after welding except for the alloy Grades 6005A, 6061 and 6082. These are to be allowed to naturally age at ambient temperature for a period of 72 hours from the completion of welding, before the testing is carried out. A second solution heat treatment is not permitted. The time and temperature of any ageing treatment is to be reported in detail.

**8.2 Initial approval tests for manual, semi-automatic and automatic multi-run techniques**

8.2.1 Plate of the corresponding type of aluminium alloy and of appropriate thickness is to be used for the preparation of the weld test assemblies.

8.2.2 The welding current and power requirements are to be within the range recommended by the manufacturer and are to be reported.

8.2.3 Welded assemblies are to be prepared and tested in accordance with 8.3, 8.4 and 8.5.

**8.3 Deposited metal test assemblies**

8.3.1 One assembly is to be prepared in the downhand position as shown in Fig.8.3.1.

8.3.2 The chemical composition of the plate used for the assembly is to be compatible with the weld metal.

8.3.3 The thickness of the plate used and the length of the assembly are to be appropriate to the welding process. The plate thickness is to be not less than 12 [mm].

8.3.4 For the approval of filler wire/gas and electrode wire/gas combinations for manual or semi-automatic welding by GTAW or GMAW, one test assembly is to be welded using any size of wire within the range for which approval is sought.

8.3.5 For automatic multi-run approval, one test assembly is to be welded by the respective process using the recommended diameter of wire.

8.3.6 The weld metal is to be deposited in multi-run layers in accordance with normal practice. The direction of deposition of each layer is to alternate from each end of the plate.

8.3.7 The deposited weld metal in each test assembly is to be analysed and reported including the contents of all significant elements. The elements reported will be dependent on the type of aluminium alloy for which approval of the consumables is requested. The results of the analysis are to be within the tolerances specified in the standards and by the manufacturer.

**8.4 Butt weld test assemblies**

8.4.1 Plate of the corresponding type of aluminium alloy and of an appropriate thickness is to be used for the preparation of the test assemblies.

**Table 8.4.1 : Requirements for the transverse tensile and bend tests**

| Grade | Base material used for the test | Tensile strength $R_m$ [N/mm$^2$] min. | Former diameter | Bending angle [1] [°] min. |
|---|---|---|---|---|
| RA/WA | 5754 | 190 | 3t | 180 |
| RB/WB | 5086 | 240 | 6t | |
| RC/WC | 5083<br>5383 or 5456<br>5059 | 275<br>290<br>330 | 6t | |
| RD/WD | 6061, 6005A or 6082 | 170 | 6t | |

1) During testing, the test specimen shall not reveal any one single flaw greater than 3 [mm] in any direction. Flaws appearing at the corners of a test specimen shall be ignored in the evaluation, unless there is evidence that they result from lack fusion.

8.4.2 In order to ensure sound and representative welds, it is essential that test assemblies are cleaned and degreased prior to welding. Assemblies as shown in Fig.8.4.2 are to be prepared for each welding position (downhand, horizontal-vertical, vertical-upward, vertical-downward and overhead) for which the consumable is recommended by the manufacturer; except that consumables satisfying the requirements for downhand and vertical-upward positions will be considered as also complying with the requirements for the horizontal-vertical position.

Back sealing runs are allowed in single V weld assemblies. In case of double V assembly both sides shall be welded with the same welding position.

8.4.3 One additional assembly, as shown in Fig.8.4.3, is to be prepared for welding in the downhand position. The assembly is to be welded using, for the first run, wire of the smallest diameter recommended by the manufacturer and for the remaining runs, wire of the largest diameter to be approved.

8.4.4 The manufacturer's recommended procedures are to be used in making the welds and are to be reported.

8.4.5 The welded assemblies should be subjected to both radiographic and visual examination, aided where necessary by dye penetrant testing, to ensure that the welds are free from cracks and porosity.

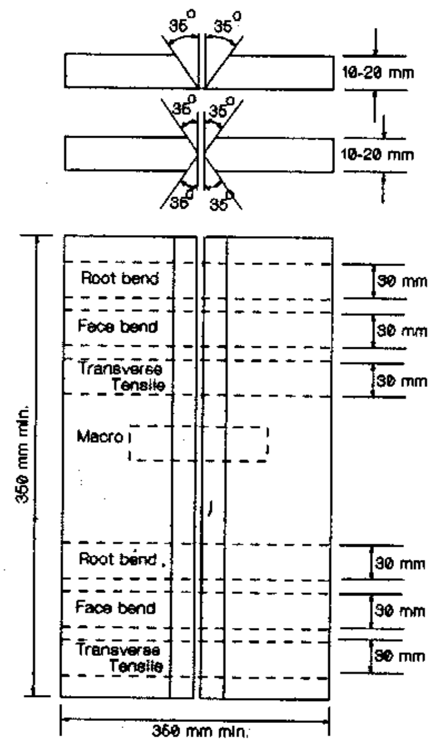



**Fig.8.4.2 : Butt weld test assembly (positional welding)**

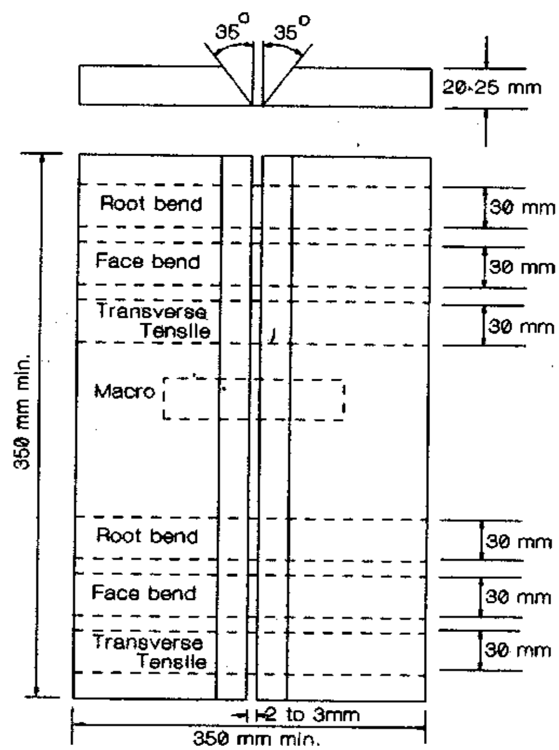



**Fig.8.4.3 : Additional butt weld assembly (downhand)**

8.4.6 The test specimens are to be taken from the welded assemblies as shown in Fig.8.4.2 and Fig.8.4.3. For each assembly they are to comprise:

2 transverse tensile specimens;

1 macro specimen;

2 face bend specimens; and

2 root bend specimens.

8.4.7 All tensile test specimens should have a tensile strength not less than the respective value shown in Table 8.4.1. The position of each fracture is to be reported.

8.4.8 The bend test specimens are to be bent around a former having a diameter not more than the number of times the thickness (t) of the test specimen as shown in Table 8.4.1.

**8.5 Fillet weld test assemblies**

8.5.1 Assemblies are to be prepared and tested in accordance with the appropriate requirements of 2.4 except that the plates are to be of the aluminium alloy for which approval is required, that no hardness tests are required and that for automatic multi-run approval only one fillet weld bead is to be made using the recommended wire diameter. In this case, the bead size should be as large as the maximum single bead size recommended by the manufacturer for fillet welding.

8.5.2 The results of examination of the macro specimens and the fractured fillet welds are to be reported in accordance with 2.4.3 and 2.4.5. Particular attention is to be given to the presence of any porosity.

**8.6 Initial approval tests for two-run technique**

8.6.1 Two butt weld test assemblies are to be prepared using the following plate thicknesses as shown in Fig.8.7.1:

क) one with the maximum thickness for which approval is requested;

ख) one with a thickness approximately one half to two thirds that of the maximum thickness.

**8.7 Annual tests**

8.7.1 Annual repeat tests are to consist of preparation and testing of the deposited weld metal test assembly as prescribed in 8.3 (Fig.8.3.1) and of the downhand buttweld assembly according to 8.4 (Fig.8.4.2).

**Annex 2**

**General Hull Requirements**

**Contents**



**Annex 2**

**Contents**

**Chapter 1**

**General, Definitions, Documentation**



**Chapter 2**

**Materials of Construction**

## Chapter 15

## Hull Inspection, Workmanship and Testing



## Chapter 1

## General, Definitions, Documentation

***Contents***



### Section 1

### General

**1.1 Scope**

1.1.1 The requirements in this part apply to all-welded, single hull steel ships of normal form, proportions and speed for operation in inland waterways.

1.1.2 For additional class notations relating to various ship types, requirements as per Pt.5 are to be complied with.

1.1.3 Ships of unconventional forms and proportions or intended for carriage of cargoes not covered by the requirements or to be engaged in special service will receive individual consideration based on the general principles. In these cases, however, additional calculations and/or model testing may be required to be carried out and submitted for approval.

1.1.4 Proposals for use of alternative materials e.g. aluminium, wood, etc. for some parts of the ship shall receive special consideration.

**1.2 Equivalence**

1.2.1 Alternative arrangements, scantlings and equipment may be accepted provided they can be shown to be equivalent to the overall safety and strength standard of the requirements. Direct calculations for the derivation of the scantlings as an alternative to those derived by the formulae, may be accepted on special consideration. The calculation procedure and the assumptions made are to be submitted for approval.

**1.3 Assumptions**

1.3.1 It is assumed that significant dynamic excitation of major orders from propellers and machinery do not fall close to any natural frequency of the hull.

1.3.2 It is assumed that the ships will be competently handled and loaded as per the approved loading manuals.

## Section 2

## Definitions

### 2.1 Principal particulars

2.1.1 The forward perpendicular, F.P., is the perpendicular drawn at the intersection of the maximum load water line with the fore side of the stem.

In ships with unusual bow arrangement the position of the F.P. will be specially considered.

2.1.2 The after perpendicular, A.P., is the perpendicular drawn at the intersection of the maximum load waterline with the after side of the rudder post or the centreline of the rudder stock if there is no rudder post.

In ships with unusual stern arrangement the position of the A.P. will be specially considered.

2.1.3 Rule length, L, is the distance, [m], between the forward and after perpendiculars. However L is to be not less than 96 per cent, and need not be greater than 97 per cent of the extreme length on the maximum load waterline.

In ships with unusual bow and/or stern arrangement the Rule length, L, will be specially considered.

2.1.4 "Amidship" is at 0.5L aft of the F.P.

2.1.5 Breadth, B, is the greatest moulded breadth [m].

2.1.6 Depth, D, is the moulded depth [m], measured amidships from top of the keel to the moulded deck line of the uppermost continuous deck at side. When a rounded gunwale is arranged the depth is to be measured to the continuation of the moulded deck line.

2.1.7 Draught, T, is the moulded draught amidships corresponding to the maximum load waterline, [m].

2.1.8 The block co-efficient, $C_b$, is the moulded block co-efficient calculated as follows :-

$$C_b = \frac{\text{moulded displacement}\,[\text{m}^3]\,\text{at draught T}}{\text{LBT}}$$

2.1.9 Speed, V, is the maximum service speed in knots on draught T.

### 2.2 Structural terms

2.2.1 The general terms used in the requirements for various structural parts of the ships are defined as under:

– *Strength Deck* : In general the uppermost continuous deck. Where a superstructure deck has within 0.4L amidships, a continuous length equal to or greater than (1.5B + 3H), it is to be regarded as the strength deck instead of the covered part of the uppermost continuous deck. (H is the height of the superstructure, [m]).

– *Superstructure* : A decked structure on freeboard deck extending from side to side of the ship or with the side plating not inboard of shell plating by more than 4 per cent of the breadth B.

– *Deckhouse* : A decked structure above the freeboard deck with the side plating being inboard of the shell plating by more than 4 per cent of the breadth B.

– *Bottom Structure* : Shell plating with stiffeners and girders below the upper turn of bilge and all other elements below and including the inner bottom plating in case of the double bottom. Sloping hopper tank top is to be regarded as a bulkhead.

– *Side Structure* : Shell plating with stiffeners and girders between the upper turn of bilge and the uppermost continuous deck at side. A rounded gunwale is included in the side structure.

– *Deck Structure* : Deck plating with stiffeners, girders, and supporting pillars.

– *Girder* : A collective term for the primary supporting members, other terms include :

  – Transverses - transverse girders under the deck.

  – Web frames - side vertical girders.

  – Hatch end beams - transverse deck girders at the ends of the hatch.

  – Stringers - horizontal girders.

  – Cross-ties - girders connecting two vertical girders in a deep tank.

  – Floor - bottom transverse girders.

– *Stiffener* : A collective term for secondary supporting members; other terms being :

  – Frames.

  – Bottom, inner bottom, side or deck longitudinals.

  – Reverse frame - transverse stiffener on the inner bottom.

  – Horizontal or vertical bulkhead stiffeners.

  – Other terms are defined in the appropriate Chapters.

### 2.3 Material factor

2.3.1 Material factor, k, a factor depending on material strength is defined in Ch.2.

## Section 3

## Documentation

### 3.1 General

3.1.1 Documentation is to be submitted as per the following paragraphs. In case of certain ship types additional documentation may be required as per Pt.5.

3.1.2 The documents should be submitted in triplicate, one copy of which shall be returned.

### 3.2 Plans for information

3.2.1 The following supporting plans and calculations are to be submitted for information :

- General arrangement.
- Tank plan.
- Capacity plan.
- Lines plan and Hydrostatic curves or tables.
- Docking plan.

### 3.3 Additional information

3.3.1 The following additional information is to be submitted as necessary for strength calculations:

- Maximum values of still water bending moments and shear forces.
- Lightship weight and its longitudinal distribution.
- Bonjeans data.
- Stowage factor and angle of repose of bulk cargoes to be carried.
- Masses and unbalanced moments of heavy machinery components e.g. engines, cranes, winches etc.

### 3.4 Plans for approval

3.4.1 Plans as relevant are to be submitted for approval as indicated in Table 3.4.1. These should as far as practicable be complete in all necessary details.

### 3.5 Plans to be kept on board

3.5.1 A copy of the final approved loading manual and suitable scantlings plans including details of corrosion control system; if any, are to be placed on board the ship.

3.5.2 To facilitate the ordering of materials for repairs, plans showing the disposition and extent of high tensile steel and steel of grades other than Grade A, along with the information relating to their physical and mechanical properties, recommended working, treatment and welding procedures etc. are to be placed on board.

| Table 3.4.1 : Plans for approval | |
|---|---|
| **Plan** | **Including Information On** |
| Loading manual [1)] | details of loading in all contemplated loading conditions and resulting SWBM, SF & Torsional Moments (TM)<br>design values of SWBM, SF & TM |
| Midship section<br>Other transverse sections<br>Longitudinal sections & decks<br>Shell expansion & framing plan | main particulars (L,B,D,T,$C_b$,V)<br>equipment specification<br>complete class notation applied for<br>spacing of stiffeners<br>deck Loads, if other than those specified in the requirements<br>openings on the deck<br>openings on the shell<br>material grades |
| Double bottom | indication of access<br>height and location of overflows<br>loading on inner bottom |
| Watertight subdivision bulkheads & watertight tunnels | openings and their closing appliances |
| Aft-end structure<br>Sternframe or sternpost<br>Propeller shaft brackets<br>Aft peak tank | propeller outline<br>propeller thrust<br>structural details in way of rudder and propeller bearings<br>height and location of overflow |
| Engine room structure<br>Engine and thrust block seatings | type, power and r.p.m. of propulsion machinery<br>weight of machinery, boilers, etc. |
| Fore-end construction<br>Fore peak tank | openings on non-watertight bulkheads and diaphragm plates<br>height and location of overflows |
| Oil tight/water tight and partition bulkheads in cargo tanks, ballast tanks and deep tanks | intended tank contents & their densities<br>height and location of overflow/air pipes<br>tanks intended to be partially filled<br>corrosion protection; if any |
| Superstructures, deckhouses and machinery casings | height of sills from deck and closing appliances for companion ways |
| Hatchways<br>Hatch covers | position and type<br>loads if different from those specified in the requirements<br>sealing and securing arrangement, spacing of bolts or wedges |
| Rudder, stock and tiller<br>Steering gear arrangement | speed of the ship (ahead & astern)<br>material of bearings, coupling bolts, stock and the locking device<br>rudder carrier. |
| Masts & derrick posts<br>Support structure for masts, derrick posts & cranes | derrick length and loading<br>dimensions and positions of stays and shrouds<br>quality of material |

| | |
|---|---|
| Testing plan of tanks & bulkheads | |
| Welding details | |
| **Notes:**<br>1) See Chapter 5, Section 6.<br>2) One drawing may contain more than one of the items from each group | |

## Chapter 2

## Materials of Construction

***Contents***

***Section***



## Section 1

## General

### 1.1 Scope

1.1.1 The requirements relate, in general, to the construction of steel ships. Consideration will however be given to the use of other materials also.

1.1.2 The materials used in the construction of the ship are to be manufactured and tested in accordance with the requirements of Annex 1 - Requirements for inspection and testing of materials. Materials for which provision is not made may be accepted, provided that they comply with an approved specification and such tests as may be considered necessary.

### 1.2 Steel

1.2.1 Ordinary hull structural steel is a hull structural steel with a minimum yield stress of 235 [N/mm$^2$] and a tensile strength generally in the range of 400-490 [N/mm$^2$].

For ordinary hull structural steel, the **material factor `k'** is to be taken as 1.0.

1.2.2 Steels having a yield stress of 265 [N/mm$^2$] and higher, are regarded as higher tensile steels. Where higher tensile steel is used, the hull girder section modulus and the local scantlings may be reduced in accordance with the relevant requirement. For this purpose, a material factor 'k', is to be taken as follows:

k = 0.78 for steel with a minimum yield stress of 315 [N/mm$^2$]

k = 0.72 for steel with minimum yield stress of 355 [N/mm$^2$]

1.2.3 Where steel castings or forgings are used for sternframes, rudderframes, rudder stocks, propeller shaft brackets and other major structural items, they are to comply with Annex 1 - Requirements for inspection and testing of materials.

### 1.3 Grades of steel

1.3.1 The ships covered by these Rules are generally to be constructed of Grade 'A' steel. However, for materials of over 20 [mm] in thickness used in highly stressed areas, grades of steel with higher levels of notch toughness (Grades 'B', 'D' or 'E') may be required dependent on the stress pattern associated with its location.

### 1.4 Aluminium

1.4.1 Where seawater resisting aluminium alloys manufactured and tested in accordance with the requirements of Annex 1 - Requirements for inspection and testing of materials are used for superstructures, deckhouses, hatch covers or other structural components, scantlings equivalent to steel are to be derived as follows:

plating thickness, $t_a = t_s \sqrt{k_a}$

section modulus of stiffeners, $Z_a = Z_s \cdot k_a$

where,

$t_a$, $t_s$ = plating thickness of aluminium and mild steel respectively.

$Z_a$, $Z_s$ = section modulus of aluminium and mild steel stiffeners respectively.

$$k_a = \frac{235}{\sigma_a}$$

$\sigma_a$ = 0.2% proof stress or 70% of the ultimate strength of the aluminium material, whichever is lesser [N/mm$^2$].

1.4.2 The smaller modulus of elasticity of aluminium is to be taken into account, when determining the buckling strength of structural elements subjected to compression and the deflections, where relevant.

## Section 2

## Corrosion Protection

### 2.1 General

2.1.1 All steelwork, except inside tanks intended for the carriage of oil or bitumen, is to be protected against corrosion by application of suitable coating.

For protection required in salt water ballast spaces, See 2.5.

For protection required in holds of dry bulk cargo carriers, see Pt.5, Ch.1.

For the protection required in tanks carrying chemicals or other special cargoes, see Pt.5, Ch.3.

2.1.2 Where bimetallic connections are made, measures are to be incorporated to preclude galvanic corrosion.

### 2.2 Surface preparation, prefabrication pri-mers, and paints or coatings

2.2.1 Steelwork is to be cleared of millscale and suitably cleaned before the application of surface paints and coatings. It is recommended that blast cleaning or other equally effective means be employed for this purpose.

2.2.2 Where a primer is used to coat steel after surface preparation and prior to fabrication, the composition of the coating is to be such that it will have no significant deleterious effect on subsequent welding work and that it is compatible with the paints or other coatings subsequently applied. Unless the primer used is type approved for this purpose, tests are to be made to determine the influence of the primer coating on the characteristics of the weld.

2.2.3 Paints or other coatings are to be suitable for the intended purpose in the locations where they are to be used. Unless previously agreed, at least two coats are to be applied.

2.2.4 The paint or coating is to be compatible with any previously applied primer, See 2.2.2.

2.2.5 Paints, varnishes and similar preparations having a nitrocellulose or other highly flammable base, are not to be used in accommodation or machinery spaces.

2.2.6 In ships intended for the carriage of oil cargoes having a flash point below 60°C (closed cup test), paint containing aluminium should not in general be used in cargo tanks, adjacent ballast tanks, cofferdams, pump rooms as well as on deck above the mentioned spaces, nor in any other areas where cargo vapours may accumulate, unless it has been shown by appropriate tests that the paint to be used does not increase the incendive sparking hazard.

### 2.3 Internal cathodic protection

2.3.1 Impressed current cathodic protection systems are not permitted in any tank.

When a cathodic protection system is to be fitted in tanks for the carriage of liquid cargo with flash point not exceeding 60°C, a plan showing details of the locations and attachment of anodes is to be submitted. The arrangements will be considered for safety against fire and explosion aspects only.

2.3.2 Particular attention is to be given to the locations of anodes in relation to the structural arrangements and openings of the tank.

2.3.3 Anodes are to be of approved design and sufficiently rigid to avoid resonance in the anode support. Weldable steel cores are to be fitted, and these are to be so designed as to retain the anode even when the anode is wasted.

2.3.4 Anodes are to be attached to the structure in such a way that they remain secure both initially and during service. The following methods of attachment would be acceptable :

a) Steel core connected to the structure by continuous welding of adequate section.

b) Steel core bolted to separate supports, provided that a minimum of two bolts with lock nuts are used at each support. The separate supports are to be connected to the structure by continuous welding of adequate section.

c) Approved means of mechanical clamping.

2.3.5 Anodes are to be attached to stiffeners, or may be aligned in way of stiffeners on plane bulkhead

plating, but they are not to be attached to the shell. The two ends are not to be attached to separate members which are capable of relative movement.

2.3.6 Where cores or supports are welded to the main structure, they are to be kept clear of the toes of brackets and similar stress raisers. Where they are welded to asymmetrical stiffeners, they are to be connected to the web with the welding kept at least 25 [mm] away from the edge of the web. In the case of stiffeners or girders with symmetrical face plates, the connection may be made to the web or to the centreline of the face plate but well clear of the free edges. However, it is recommended that anodes are not fitted to face plates of high tensile steel longitudinals.

**2.4 Aluminium and magnesium anodes**

2.4.1 Aluminium and aluminium alloy anodes are permitted in tanks used for the carriage of oil, but only at locations where the potential energy does not exceed 275 [J] (i.e. 28 [kgf m]). The weight of the anode is to be taken as the weight at the time of fitting, including any inserts and fitting devices.

2.4.2 The height of the anode is, in general, to be measured from the bottom of the tank to the centre of the anode. Where the anode is located on or closely above a horizontal surface (such as a bulkhead girder) not less than 1 [m] wide, provided with an upstanding flange or face plate projecting not less than 75 [mm] above the horizontal surface, the height of the anode may be measured above that surface.

2.4.3 Aluminium anodes are not to be located under tank hatches or tank cleaning openings unless protected by adjacent structure.

2.4.4 Magnesium or magnesium alloy anodes are permitted only in tanks intended solely for water ballast.

**2.5 Corrosion protection coatings for salt water ballast spaces**

2.5.1 In case of ships which normally carry salt water for ballast purposes, all ballast spaces, having boundaries formed by the hull envelope, are to have a suitable corrosion protection coating applied in accordance with the manufacturer's requirements.

## Section 3

## Deck Covering

**3.1 General**

3.1.1 Where plated decks are sheathed with wood or an approved composition, reductions in plate thickness may be allowed.

3.1.2 The steel deck is to be coated with a suitable material in order to prevent corrosive action, and the sheathing or composition is to be effectively secured to the deck.

3.1.3 Deck coverings in the following positions are to be of a type which will not readily ignite where used on decks :

a) forming the crown of machinery or cargo spaces within accommodation spaces of cargo ships

b) within accommodation spaces, control stations, stairways and corridors of passenger ships.

## Chapter 3

## Principles for Scantlings and Structural Details

***Contents***



## Section 1

## General

### 1.1 Application

1.1.1 Scantlings of various platings, stiffeners and girders to meet the local strength requirements are to be determined in accordance with the general principles given in this Chapter.

The design values of loads are given in chapters relevant to the structures under consideration.

1.1.2 Scantlings of hull members contributing to the longitudinal strength are also to comply with the requirements of Ch.4.

1.1.3 Scantlings of hull members subjected to compressive stresses are also to comply with the requirements of Sec.6.

### 1.2 Symbols

p = design pressure [kN/m$^2$] as given in the relevant chapters calculated at the loadpoint as given below:

Loadpoint for plates:

– midpoint of horizontally stiffened plate field

– half the stiffener spacing above the lower support of vertically stiffened plate field, or at the lower edge of plate when the thickness is changed within the plate field.

Loadpoint for stiffeners:

– midpoint of span.

Loadpoint for girders

– midpoint of load area supported by the girder.

s = stiffener spacing [mm], measured along the plating.

l = span of the stiffener, [m], in accordance with 4.1.1.

r = radius of curvature [mm].

S = span of the girder [m], in accordance with 4.1.2.

b = mean breadth [m], of the load area supported by the girder.

$h_w$ = height of web, [mm].

$b_f$ = width of flange, [mm].

$\sigma$ = allowable bending stress, [N/mm$^2$] as given in the relevant Chapters.

$\sigma_y$ = minimum yield stress of material, [N/mm$^2$], may be taken as 235 [N/mm$^2$] for normal strength steel.

k = material factor as defined in Ch.2, Sec.1.2.

E = modulus of elasticity, 2.06 x 10$^5$ [N/mm$^2$] for steel.

### 1.3 Frame spacing

1.3.1 The normal frame spacing between aft peak and 0.2L from F.P. may be taken as:

450 + 2L [mm] for transverse framing

550 + 2L [mm] for longitudinal framing.

1.3.2 In aft peak and fore peak the frame spacing is not to exceed 600 [mm] or that given in 1.3.1, whichever is less.

1.3.3 Where the actual frame spacing is higher than that mentioned above, the minimum thicknesses of various structural members as given in the requirements may require to be increased.

## Section 2

## Corrosion Additions

### 2.1 General

2.1.1 The thickness of plates, stiffeners and girders in tanks for water ballast and/or cargo oil and in holds of dry bulk cargo carriers is to be increased by a corrosion addition '$t_c$' as given in

Table 2.1.1.

2.1.2 The required corrosion addition '$Z_c$' to the section modulus of stiffeners and girders due to the thickness addition '$t_c$' mentioned above may be approximated as:

$$Z_c = \frac{t_c\, h_w\, (b_f + 0.3 h_w)}{1000}\ [cm^3]$$

**Table 2.1.1 : Corrosion addition $t_c$ [mm]**

| Item | Space Category | $t_c$ |
|---|---|---|
| Internal members within and plate boundary between spaces of the given category | Ballast tank | 1.5 [1)] |
| | Cargo oil tank | 1.5 |
| | Hold of dry bulk cargo carriers | 2 |
| Plate boundary between the two given space categories | Ballast tank/Cargo oil tank | 1.5 [1)] |
| | Ballast tank/Hold of dry bulk cargo carrier | 2 |
| | Ballast tank/Other category space | 1.0 |
| | Cargo oil tank/Other category space | 1.0 |
| | Hold of dry bulk cargo carrier/Other category space | 1.0 |

Notes:

1) Where the relevant ballast or liquid cargo tanks extend upto the exposed weather deck the minimum corrosion addition in the region extending upto 1.5 [m] below the weather deck corrosion addition is to be increased by 0.5 [mm].

2) Other category space denotes the hull exterior and all spaces other than water ballast and cargo oil tanks and holds of dry bulk cargo carriers.

## Section 3

## Plating

### 3.1 General

3.1.1 Minimum requirements of thickness of various platings are given in relevant chapters.

3.1.2 The thickness 't' of plating subjected to lateral pressure is not to be less than

$$t = \frac{15.8 s \sqrt{p}}{\sqrt{\sigma}} x 10^{-3} + t_c\ [mm]$$

3.1.3 Any tapering of thickness of platings contributing to the longitudinal strength is to be based upon linear variation of stress s allowed at specified regions.

## Section 4

## Stiffeners and Girders

### 4.1 Determination of span

4.1.1 For stiffeners, the span 'l' [m] is to be taken as the length of the stiffener between the two supporting members less the depth of stiffener on crossing panel if any. Where brackets larger than those required in 5.1.2 are fitted, the span may be determined as shown in Fig.4.1.1.

For curved stiffeners, 'l' may be based on the chord length.

4.1.2 For girders, the span 'S' [m] is to be taken as the length of the girder between the two supporting members, less the web height of in-plane girder if any, and the correction for bracket '$b_c$', as shown in Fig.4.1.2.

**4.2 Effective width of attached plating**

4.2.1 The area of the attached plating, to be used in the calculation of sectional properties of the stiffeners and girders, is to be taken as the cross-sectional area within the effective width of the attached plating.

4.2.2 The effective width of plating attached to a stiffener may be taken as the mean of spacings on either side of the stiffener.

4.2.3 The effective width of plating attached to a girder, '$b_e$' is to be taken as per the following:

$$b_e = c \cdot b$$

where,

$c = c_1$, for girders with uniformly distributed loads or with six or more evenly spaced point loads

$= c_2$, for girders with three or less evenly spaced point loads.

**Table 4.2.3 : Values of "c"**

| a/b | 0.5 | 1.0 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | ≥ 7.0 |
|---|---|---|---|---|---|---|---|---|
| $c_1$ | 0.19 | 0.38 | 0.67 | 0.84 | 0.93 | 0.97 | 0.99 | 1.00 |
| $c_2$ | 0.11 | 0.22 | 0.40 | 0.52 | 0.65 | 0.73 | 0.78 | 0.80 |

For intermediate values of a/b and number of point loads, values of 'c' may be obtained by interpolation.

a = span of the girder, for simply supported girders, [m].

= 60 per cent of span of the girder, for girders fixed at both ends, [m].

4.2.4 In case of girders on corrugated bulkheads which run across the corrugations, the effective width of attached plating is to be taken as 10% of that obtained from 4.2.3.

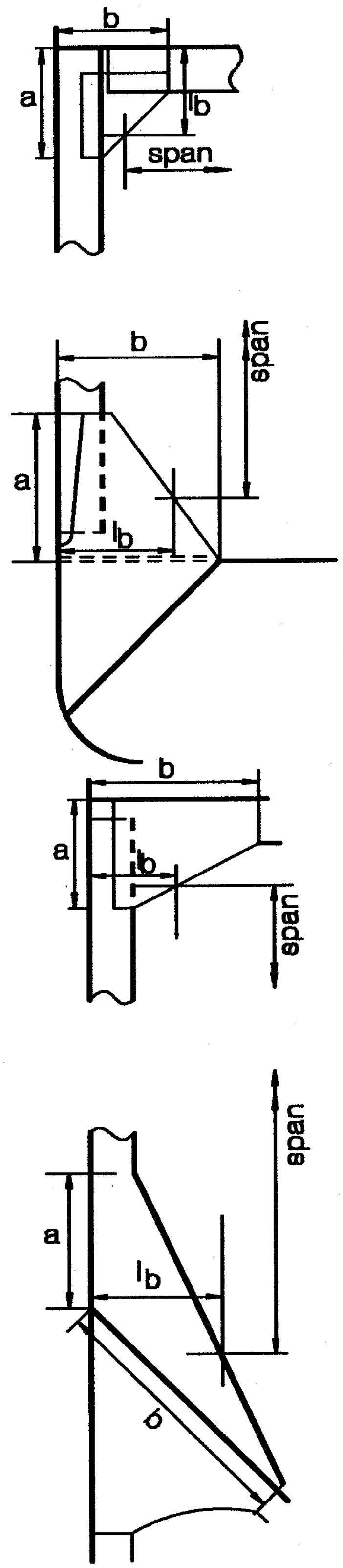
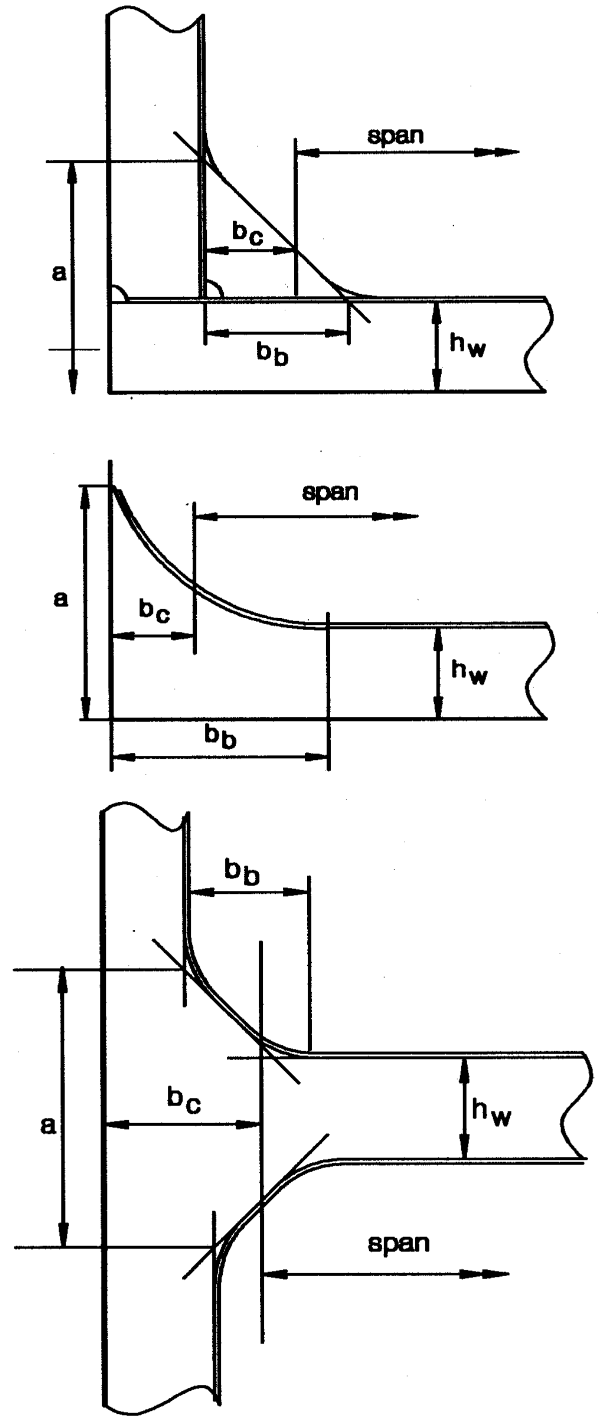



Fig.4.1.1




$$b_c = b_b\,(1 - h_w/a)$$

Fig.4.1.2

4.2.5 The effective cross sectional area of the attached plating is not to be less than that of the face plate.

**4.3 Scantlings of stiffeners**

4.3.1 The section modulus 'Z' of stiffeners subjected to lateral pressure is not to be less than:

$$Z = \frac{s.p.l^2}{m\sigma} + Z_c \ [cm^3]$$

where,

m = bending moment factor depending on the arrangement at the supports and variation of lateral pressure as given in the relevant chapters. Where not stated, the `m' value may generally be taken as:

= 12 for continuous longitudinal stiffeners

= 10 for transverse, vertical and non-continuous longitudinal stiffeners fixed at both ends.

= 8 for stiffeners simply supported at both ends.

4.3.2 Where stiffeners are not perpendicular to the plating, the section modulus as obtained from 4.3.1 is to be increased by the factor (1/cos $\alpha$), $\alpha$ being the angle between the stiffener web

and the plane perpendicular to the plating.

**4.4 Scantlings of girders**

4.4.1 The scantlings of simple girders subjected to lateral pressure which can be considered as conforming to the general beam theory are to satisfy the requirement given in 4.4.2.

4.4.2 The section modulus 'Z' of girders subjected to lateral pressure is not to be less than:

$$Z = \frac{b.p.S^2.10^3}{m\sigma} + Z_c \ [cm^3]$$

where,

m = bending moment factor depending upon the arrangement at supports and variation of lateral pressure as given in the relevant chapters. Where not stated, the 'm' value may generally be taken as 12 for continuous longitudinal girders and 10 for all other girders.

4.4.3 Where openings are cut in the girder web, they are to be away from the girder ends and scallops for stiffeners; with their centre located as near to the neutral axis of the girder as practicable. Openings of depth exceeding 25% of the girder depth or 300 [mm] and, of length exceeding the depth of the girder or 60% of the secondary stiffener spacing, are to be reinforced all around at the edge; or alternatively by providing horizontal and vertical stiffeners.

4.4.4 Girders are to be provided with adequate lateral stability by tripping brackets fitted generally at every fourth stiffener. Tripping brackets are also to be fitted at the toes of end brackets and in way of concentrated loads such as heels of pillars or cross ties.

## Section 5

## End Attachments

**5.1 End attachments of stiffeners**

5.1.1 Continuity of all stiffeners participating in longitudinal strength is to be maintained over transverse members within 0.5L amidships. Longitudinals abutting at transverse members may be accepted provided the brackets connecting the ends of the longitudinals are of adequate size and are either continuous or properly aligned.

5.1.2 Scantlings of brackets fitted on stiffeners not participating in the longitudinal strength are not to be less than the following:

– The arm lengths, 'a and b' (See Fig.4.1.1) are to be such that:

i) a, b $\geq$ 0.8 $l_b$

and

ii) a+b $\geq$ 2.0 $l_b$.

where,

$l_b = 24\sqrt{Z} + 75$ [mm]

– Thickness of unflanged bracket is to be not less than:

$t = (4.0 + 0.3\sqrt{Z}) + t_c$ [mm]

– Thickness of flanged bracket is to be not less than:

$t = (3.0 + 0.25\sqrt{Z}) + t_c$ [mm]

– Width of flange, w $\geq$ 40 + Z/25 [mm], but not to be less than 50 [mm].

where,

Z is the section modulus [cm3], of the smaller stiffener, being connected.

**5.2 End attachments of girders**

5.2.1 The end attachments and supporting structure of the girders are to provide adequate resistance against rotation and displacement of the joint and effective distribution of the load from the member. Supporting members to which the girders are being connected, may require additional strengthening to provide adequate stiffness to resist rotation of the joint. Where the end attachment provides only a low degree of restraint against rotation, the girder is generally to be extended beyond the point of support by at least two frame spaces before being gradually tapered.

Connections between girders forming a ring system are to be such as to minimize stress concentrations at the junctions Integral brackets are generally to be radiused or well rounded at the toes.

Where the face plate of the girder is not continuous over the bracket, the free edge of the bracket is to be stiffened and the face plate of the girder is to be extended well beyond the toe of the bracket.

5.2.2 The thickness 't' of brackets on girder is not to be less than that of the girder web.

The arm length 'a' including the depth of girder is not to be less than:

a = 83 $\sqrt{(Z/t)}$ [mm];

where,

Z = the section modulus [$cm^3$], of the girder to which the bracket is connected.

The cross sectional area '$A_f$' of the face plate on the girder bracket is not to be less than:

$$A_f = 0.001\, l_f\, t\ [cm^2]$$

where, $l_f$ is the length [mm], of the free edge of the bracket.

Additional stiffeners parallel to the bracket face plate are to be fitted on webs of large brackets. The arm length of an unstiffened triangular end panel of bracket is generally not to exceed 100 t [mm].

**Section 6**

**Buckling**

**6.1 General**

6.1.1 The critical buckling stress '$\sigma_{cr}$' of plate panels and other members subjected to compressive loads is to be such that:

$$\sigma_{cr} \geq \frac{\sigma_c}{\eta}$$

where,

$\sigma_c$ = applied compressive stress

$\eta$ = 1.0 for deck, longitudinally stiffened side shell and single bottom plating

= 0.9 for bottom, inner bottom plating in double bottom and transversely stiffened side shell plating

$= \dfrac{0.7}{1 + l_m/i}$ (need not be taken smaller than 0.3);

- for axially loaded members such as pillars, cross-ties, panting beams etc., in general. - to be reduced by 15 per cent where the loads are primarily dynamic in nature.
- for '$l_m$' and 'i' See 6.2.2.

6.1.2 The critical compressive buckling stress '$\sigma_{cr}$' determined as follows is not to be less than the maximum compressive stress developed in the members under consideration.

$\sigma_{cr} = \sigma_E$ when $\sigma_E \leq 0.5\ \sigma_y$

$$= \sigma_y \left(1 - \frac{\sigma_y}{4\sigma_E}\right) \text{ when } \sigma_E > 0.5\sigma_y$$

where,

$\sigma_E$ = ideal elastic buckling stress as per Sec.6.2.

**6.2 Ideal elastic buckling stress**

6.2.1 The $\sigma_E$ value for platings may be taken as:

$$\sigma_E = 0.9\, K\, E\left[\left(t - t_c\right)/s\right]^2 \ [\text{N/mm}^2]$$

where,

$$K = \frac{8.4}{\psi + 1.1}$$

- for plating with stiffeners in the direction of the compressive stress

$$= C\left[1 + \left(\frac{s}{1000\, x\, l}\right)^2\right]^2 \frac{2.1}{\psi + 1.1}$$

- for platings with stiffeners in the direction perpendicular to the compressive stress

$\psi$ = ratio between the smaller and the larger values of the compressive stress assuming a linear variation (See Fig.6.2.1)

C = 1.30 when plating is stiffened by floors or deep girders

= 1.21 when stiffeners are angles or T sections

= 1.10 when stiffeners are bulb flats

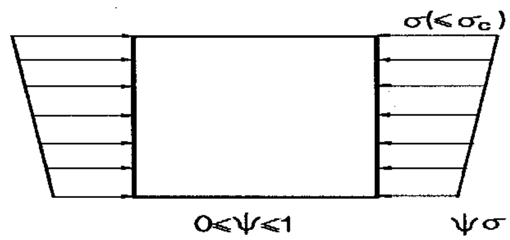



Fig. 6.2.1

= 1.05 when stiffeners are flat bars

s = shorter side of plate panel, [mm]

l = longer side of plate panel, [m]

6.2.2 The value for axially loaded members may be taken as:

$\sigma_E = 0.001\ C\ E\ (i/l_m)^2$ [$N/mm^2$]

C = 1.0 for both ends hinged

= 2.0 for one end fixed

= 4.0 for both ends fixed

i = radius of gyration of the member, [cm].

= $\sqrt{(I/a)}$

I = moment of inertia of the member, [$cm^4$], about the axis perpendicular to the direction of buckling being considered

a = cross sectional area of the member, [$cm^2$]

$l_m$ = length of the member, [m].

Where end connections of a member are different with respect to the two principal axes, $\sigma_E$ is to be found out for both cases using appropriate values of 'C' and 'I'.

## Chapter 4

## Longitudinal Strength

***Contents***

| ***Section*** | |
|---|---|
| *1* | *General* |
| *2* | *Vertical Bending Moments* |
| *3* | *Hull Section Modules and Moment of Inertia* |
| *4* | *Openings in Longitudinal Strength Members* |

## Section 1

## General

### 1.1 Application

1.1.1 Scantlings of hull members contributing to longitudinal strength are to comply with the requirements given in this Chapter. These members are also to comply with the requirements of buckling strength given in Ch.3, Sec.6 and of local strength given in relevant chapters.

1.1.2 Still water bending moments are to be calculated for all ships with unusual or non-uniform weight or cargo distribution and for other ships of L ≥ 60 m.

Such ships are to be provided with an approved loading manual which describes the loading conditions on which the design is based and also gives the values of still water bending moments and permissible limits.

### 1.2 Symbols

L, B, T, k as defined in Ch.1, Sec.2.

$I_n$ = moment of inertia of hull girder, [cm$^4$], about the transverse neutral axis at the section under consideration.

$Z_n$ = vertical distance [m] of the horizontal neutral axis above base line.

$M_s$ = design still water bending moment [kN-m] as given in 2.1.2.

$M_w$ = rule wave bending moment [kN-m] as given in 2.2.1.

## Section 2

## Vertical Bending Moments

### 2.1 Still water bending moment

2.1.1 Still water bending moments are to be calculated for the following loading conditions as a minimum:

a) Fully loaded condition with design cargo distribution(s)

b) Light condition with full consumables, stores, crew and ballast, if any.

In addition other loading conditions which may be more onerous, e.g. intermediate conditions of special loading or discharging sequences, are to be investigated.

2.1.2 The design value of still water bending moment Ms at 0.4L amidships is to be taken as the greater of the following:

a) The maximum of sagging or hogging still water bending moments obtained for the loading conditions specified in Sec.2.1.1, and

b) 0.375 $L^2B$ [kN-m]

At locations outside 0.4L amidships the design value of still water bending moment Ms may be linerally reduced to zero at perpendiculars.

### 2.2 Wave load conditions

2.2.1 The rule vertical wave bending moment $M_w$ for 0.4L amidships is to be taken as

$$M_w = C L^2 B \text{ [kN} - \text{m]}$$

where,

C = coefficient as per Table 2.2.1.

**Table 2.2.1**

| **Zone** | **Coefficient C** |
|---|---|
| 1 | 0.30 for L ≤ 20 m<br>0.3 + 0.005 (L-20) for 20 < L < 60<br>0.5 for L ≥ 60 m |
| 2 | 0.3 |
| 3 | 0.15 |

At locations outside 0.4L amidships, the value of rule wave bending moment Mw is to be linerally reduced to zero at perpendiculars.

## Section 3

## Hull Section Modulus and Moment of Inertia

### 3.1 Calculation of section properties

3.1.1 When calculating the moment of inertia and section moduli, the net sectional area (after deduction for openings) of all continuous longitudinal strength members is to be taken into account. Small isolated lightening holes in girders need not be deducted.

Superstructures not forming strength deck (See Ch.1, Sec.2.2), deckhouses, bulwarks and non-continuous longitudinal hatch coamings are not to be included in the above calculations.

In case of ships with continuous trunks or longitudinal hatch coamings, their net sectional area may be included in the calculations provided they are effectively supported by longitudinal bulkheads or deep girders. The section modulus at deck however, is then to be calculated as given in 3.1.3.

3.1.2 The main strength members included in the calculation of hull moment of inertia and section modulus are to extend continuously through the cargo region and sufficiently far towards the ends of the ship. Longitudinal bulkheads are to terminate at effective transverse bulkheads and large transition brackets are to be fitted in line with the longitudinal bulkheads.

3.1.3 The midship section modulus 'Z' at deck or bottom about the transverse neutral axis is to be obtained as follows:

$$Z = I_n / (100.z) \quad [cm^3]$$

where,

z = the vertical distance [m] from the horizontal neutral axis upto the strength deck at side or the base line, as relevant.

However, in case of ships where continuous trunks or longitudinal hatch coamings are to be included in the section modulus calculation as per Sec.3.1.1, the distance z for calculation of modulus at deck is to be taken as the greater of the following:

z = z as above

$z = z_n [0.9 + 0.2\ y/B]$

where,

$z_n$ = the vertical distance from the horizontal neutral axis to top of continuous strength number.

y = athwartship distance from the centreline of the ship to the side of the strength member.

$z_n$ and y are to be measured to the point giving the largest value of z.

### 3.2 Extent of high tensile steel

3.2.1 Where high tensile steels are used in the main hull structure in order to reduce the section modulus requirement, the vertical and longitudinal extent of its use is to be such that adjacent structure made of ordinary hull structural steel is not stressed beyond the stress level permissible for ordinary steel.

### 3.3 Section modulus requirement

3.3.1 At any transverse section, the hull section modulus Z, about the transverse neutral axis for the still water bending moments $M_s$ given in 2.1 and wave bending moments $M_w$ given in 2.2, is not to be less than:

$$Z = \left(\frac{M_s + M_w}{\sigma_L}\right) x\ 10^3 \quad [cm^3]$$

where,

$\sigma_L$ = 175/k [N/mm$^2$] within 0.4L amidships

= 125/k [N/mm$^2$] within 0.1L from A.P. and F.P.

Between the specified regions $\sigma_L$ is to be obtained by linear interpolation.

3.3.2 Scantlings of all continuous longitudinal members of hull girder based on the section modulus requirement in 3.3.1 are to be maintained within 0.4L amidships.

In the region outside 0.4L amidships, the scantlings are to be gradually tapered to the local requirements at ends.

### 3.4 Moment of inertia requirement

3.4.1 The moment of inertia $I_n$ of the hull section about the transverse neutral axis, at midship, is not to be less than:

$$I_n = 3\ L\ .\ Z \quad [cm^4]$$

where,

Z = Hull section modulus amidships as required by 3.3.1.

## Section 4

## Openings in Longitudinal Strength Members

### 4.1 Locations

4.1.1 As far as practicable, openings are to be avoided in the keel plate and in the bilge plate within 0.6L amidships.

4.1.2 Openings in the strength deck within 0.6L amidships are as far as practicable to be located inside the line of large hatch openings. Necessary openings outside this line are to be kept well clear of the ship's side and hatch corners.

4.1.3 Small openings are generally to be kept well clear of other openings in the longitudinal strength members.

### 4.2 Reinforcements

4.2.1 All openings are to be adequately framed and arrangements in way of corners and openings are to be such as to maintain structural continuity and minimize the creation of stress concentrations.

Corners of hatchways are to be reinforced as given in Ch.8, Sec.2. Smaller openings in the strength deck and outer bottom within 0.6L amidships are to be reinforced as given in 4.2.2 to 4.2.5 below. The area of these reinforcements is not to be included in the sectional areas used in the section modulus calculation.

4.2.2 Circular openings with diameter equal to or greater than 0.325 [m] are to have edge reinforcement having sectional area A not to less than:

$$A = 2.5\ b.t.\ \ [cm^2]$$

where,

b = diameter of the opening [m]

t = thickness of the plating [mm].

4.2.3 Elliptical openings are to have their major axis in the fore and aft direction. Where the ratio of the major axis to minor axis is less than 2, the openings are to be reinforced as given in 4.2.2 taking b as the breadth of the opening (minor axis).

4.2.4 Rectangular openings are to have their corners well rounded. Where corners are of circular shape the radius is not to be less than 20 per cent of the breadth of the opening and the edges are to be reinforced as given in 4.2.2 taking b as the breadth of the opening.

Where corners are of elliptical shape as given in 4.2.3 or of streamlined shape as given in 4.3, the reinforcement will generally not be required provided that the transverse extension of the curvature, a, shown in Fig. 4.3.2 is not less than:

$$a = 0.15b\ \ [m]$$

4.2.5 Openings in side shell subjected to large shear stresses are to be of circular shape and are to be reinforced as given in 4.2.2 irrespective of the size of opening.

### 4.3 Hatchway corners

4.3.1 Where corners are of circular shape, the radius r within 0.6L amidships is not to be less than

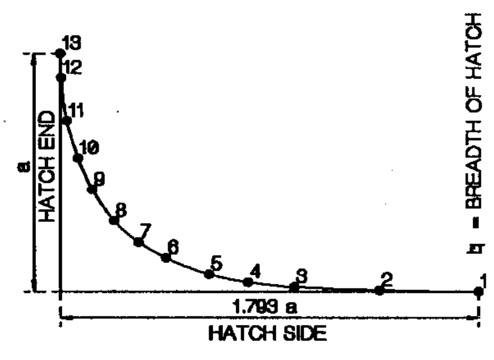
$$r = 0.05\ b\ [m],\ \text{minimum}\ 0.3\ [m]$$

where,

b = breadth of the hatchway [m]

4.3.2 Where corners are of streamlined shape, as given by Fig. 4.3.2, the transverse extension of the curvature, a, is not to be less than

$$a = 0.05\ b\ [m],\ \text{minimum}\ 0.3\ [m]$$




| Ordinates of steamlined corner | | |
|---|---|---|
| **Point** | **Abscissa, x** | **Ordinate, y** |
| 1 | 1.793a | 0.0 |
| 2 | 1.381a | 0.002a |
| 3 | 0.987a | 0.021a |
| 4 | 0.802a | 0.044a |
| 5 | 0.631a | 0.079a |
| 6 | 0.467a | 0.131a |
| 7 | 0.339a | 0.201a |
| 8 | 0.224a | 0.293a |
| 9 | 0.132a | 0.408a |
| 10 | 0.065a | 0.548a |
| 11 | 0.022a | 0.712a |
| 12 | 0.002a | 0.899a |
| 13 | 0.0 | 1.000a |

**Fig.4.3.2 : Streamlined deck corner**

# Chapter 5

## Bar Keel, Stem and Sternframes

***Contents***



## Section 1

## General

### 1.1 Scope

1.1.1 This chapter provides requirements for bar keel, bar stem, stern frames and shaft brackets.

### 1.2 Material

1.2.1 All steel plates and sections, castings and forgings used in the constructions are to be tested and approved in accordance with the requirements of Ch.3, Ch.4 and Ch.5 of Annex 1. Material grades for plates and sections are to be selected as per Ch.2.

1.2.2 Bar keels and stems may either be steel castings or forgings or rolled plates or bars.

1.2.3 Sternframes, rudder horns and shaft brackets may be constructed of cast or forged steel or may be fabricated from plates.

### 1.3 Symbols

1.3.1 L, T as defined in Ch.1, Sec.2.

## Section 2

## Bar Keel

### 2.1 Scantlings

2.1.1 The scantlings of bar keel are not to be less than :

Depth = 75 + 0.75 L [mm]

Thickness = 10 + 0.4 L [mm]

Minor deviations from the above values may be accepted provided the required sectional area is maintained.

## Section 3

## Stem

### 3.1 Bar stem

3.1.1 The cross sectional area 'A' of a bar stem, below the summer load waterline, is not to be less than

$A = 0.6L$ [cm$^2$]; or 12 [cm$^2$]

- whichever is greater.

### 3.2 Plate stem

3.2.1 The thickness 't' of the plate stem below the summer load waterline is not to be less than:

$t = ( 0.08 L + 5.0 )$ [mm]

3.2.2 The thickness of the plate stem may be gradually reduced to that of the side shell at the stem head.

3.2.3 The plate stems are to be supported by horizontal diaphragms spaced not more than 1.0 [m] apart. Where the stem plate radius is large, a centreline stiffener or web is to be provided.

## Section 4

## Stern Frames

### 4.1 General

4.1.1 Sternframes, shaft brackets etc. are to be designed such that they are effectively integrated into the ship's structure.

4.1.2 In castings, sudden changes of section or possible constrictions to the flow of metal during castings are to be avoided. All fillets are to have adequate radii, which in general should not be less

than 50 to 75 [mm], depending on the size of the casting.

4.1.3 Fabricated and cast steel sternframes are to be strengthened at intervals by webs spaced not more than 700 [mm] apart. In way of the upper part of the sternframe arch, these webs are to line up with the floors.

4.1.4 Rudder posts and propeller posts are to be connected to floors of increased thickness.

4.1.5 It is recommended that the after body of the ship be so shaped as to ensure adequate flow of water to the propeller so as to prevent uneven formation of eddies, as far as possible.

**4.2 Sternframes**

4.2.1 The scantlings of the propeller posts are not to be less than the following:

Forged propeller posts (see Fig. 4.2.1 (a))

$A = (8 + 0.4L)\ T\ [cm^2]$ for $L < 60$ [m]

$= 32\ T\ [cm^2]$ for $L > 60$ [m]

Fabricated propeller posts (see Fig. 4.2.1 (b))

$l = 150\ \sqrt{T}$ [mm]

$w = 100\ \sqrt{T}$ [mm]

$r = 18\ \sqrt{T}$ [mm]

$t_1 = 11\ \sqrt{T}$ [mm]

$t_w = 5\ \sqrt{T}$ [mm]

Cast steel propeller posts ( see Fig. 4.2.1 (c))

$l = 125\ \sqrt{T}$ [mm]

$w = 85\ \sqrt{T}$ [mm]

$r = 20\ \sqrt{T}$ [mm]

$t_1 = 12\ \sqrt{T}$ [mm]

$t_2 = 14\ \sqrt{T}$ [mm]

$t_w = 7\ \sqrt{T}$ [mm].

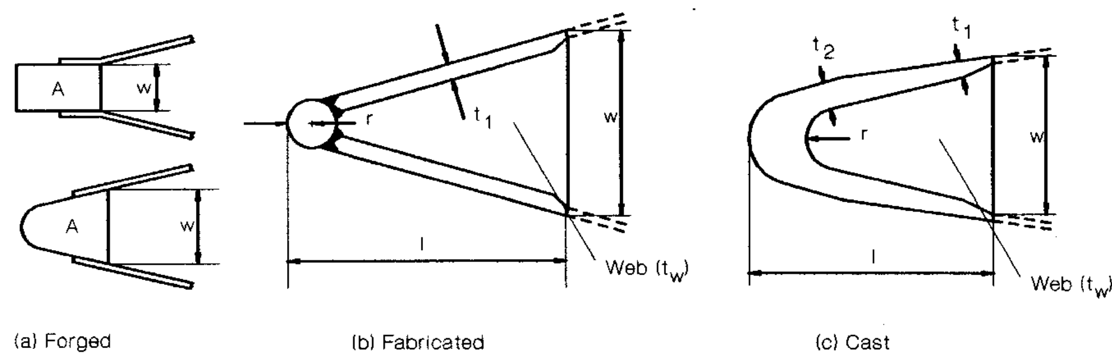



**Fig.4.2.1 : Types of propeller posts**

Where the sections adopted differ from the above, the section modulus about the longitudinal axis is to be equivalent to that with the Rule scantlings.

On sternframes without solepieces, the modulus of the propeller post, about the longitudinal axis, may be gradually reduced by 15 per cent below the propeller boss, provided the thicknesses are maintained as above.

4.2.2 The wall thickness of the boss '$t_b$' in the propeller post is not to be less than :

$$t_b = 0.25\ d_{ts} + 12\ [mm]$$

where,

$d_{ts}$ = Rule diameter of tail shaft, [mm].

In fabricated stern frames the connection of the propeller post to the boss is to be by full penetration welds.

**4.3 Sole piece**

4.3.1 The section modulus 'ZT' of the sole piece against transverse bending is not to be less than

$$Z_T = \frac{1}{90}\ \frac{c F_r\ x}{b}\ [cm^3]$$

where,

$F_r$ = Rudder force [N] as defined in Pt.3, Ch.12, Sec. 3

x = distance of the cross section under consideration from the centre line of rudder stock, [m]. 'x' is not to be taken as less than a/2.

a, b, c = as shown in Figures 4.3.1 (a) and (b) [m].

The above requirement of $Z_T$ is to be increased by 15 per cent for cast steel solepieces.

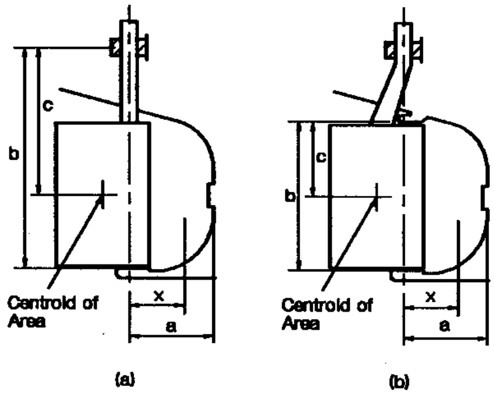



Fig.4.3.1 : Open stern frame

4.3.2 The section modulus '$Z_v$' of the sole piece against vertical bending is not to be less than :

$$Z_v = \frac{Z_T}{2} \ [\text{cm}^3]$$

4.3.3 The sectional area of sole piece is not to be less than:

$$A_s = \frac{1}{5400} \cdot \frac{c.F_r}{b} \ [\text{cm}^2]$$

4.3.4 The sole piece is to extend at least two frame spaces forward of the forward edge of the propeller boss and beyond this, the cross section of the extension is to be gradually reduced to that necessary for an efficient connection to the keel plate. Fabricated solepieces are to have adequate internal stiffening.

**4.4 Shaft brackets**

4.4.1 Where the propeller shafting is exposed to the sea for some distance clear of the main hull, it is generally to be supported adjacent to the propeller by independent brackets having two arms. It is recommended that the angle included between the arms differs from the angle included between the propeller blades. In very small ships the use of single arm brackets will be considered.

4.4.2 Fabricated brackets are to be designed to avoid or reduce the effects of hard spots and ensure a satisfactory connection to the hull structure. The connection of the arms to the bearing boss is to be by full penetration welding.

4.4.3 Generally, bracket arms are to be carried through the shell plating and attached to floors or girders of increased thickness. The shell plating in way of shaft brackets is to be increased in thickness to a minimum of 1.5 times the Rule bottom shell plating thickness amidships. The connection of the bracket arms to the shell plating is to be by full penetration welding.

4.4.4 The scantlings of solid or built-up shaft brackets are to comply with the following:

$t = 0.4\ d_{ts}$ [mm]

$A = 4.5\ d_{ts}^2 \cdot 10^{-3}$ [cm$^2$]

$Z_T = 30\ d_{ts}^3 \cdot 10^{-6}$ [cm$^3$]

where,

t = thickness of the bracket arms

A = cross sectional area of the bracket arms

$Z_T$ = Section modulus of the bracket arms against transverse bending

## Chapter 6

## Bottom Structure

*Contents*



## Section 1

## General

### 1.1 Scope

1.1.1 The scantlings and arrangement of bottom structure as defined in Ch.1, Sec.2 are to comply with the requirements given in this Chapter.

### 1.2 Symbols

$L, B, T, C_b, k$ as defined in Ch.1, Sec.2.

s = spacing of stiffeners, [mm]

l = span of stiffeners, [m]

b = spacing of girders, [m]

S = span of girders, [m]

$t_c$, $Z_c$ are corrosion additions to the thickness and section modulus respectively, as given in Ch.3, Sec.2.1.

$$f_B = \frac{Z_R}{Z_B}$$

where,

$Z_R$ = Rule midship section modulus [$cm^3$] as required by Ch.4.

$Z_B$ = Actual midship section modulus [$cm^3$] provided at bottom.

## Section 2

## Structural Arrangement and Details

### 2.1 General

2.1.1 Depth of wells constructed in the double bottom, in connection with the drainage arrangement of holds, is to be kept in the minimum.

2.1.2 The continuity of the bottom, bilge and inner bottom longitudinals is to be maintained in accordance with Ch.3, Sec.5.1.1.

2.1.3 The bilge keel and the ground bar to which it is attached, are to be gradually tapered at ends and arranged to finish in way of suitable internal stiffening.

Butt welds in the bilge keel and the ground bar are to be well clear of each other and those in the shell plating.

2.1.4 The weld connections are to comply with the requirements of Ch.16.

### 2.2 Access, ventilation and drainage

2.2.1 Adequate access is to be provided to all parts of the double bottom. Where the vertical dimension of the lightening hole exceeds 50 percent of the web height adequate reinforcements are to be provided. The diameter of lightening holes in the bracket floors is not to exceed 1/3 of the breadth of the brackets. Lightening holes or manholes are normally not to be cut in floors or girders towards their ends and under large pillars or supporting structures. Manholes in innerbottom are to have reinforcement rings, and the man hole covers in the inner bottom plating in cargo holds are to be effectively protected. The edges of all holes are to be smooth.

2.2.2 To ensure the free passage of air and water from all parts of the tanks to air pipes and suctions, air and drain holes are to be provided in all non-watertight members. The air holes are to be placed as near to the inner bottom as possible and their total area is to be greater than the area of the filling pipes. The drain holes are to be placed as near to the bottom as possible.

2.2.3 The access opening to pipe tunnel is to be visible above the floor plates and is to be fitted with a rigid watertight closing device. A notice board

stating that the access opening to the pipe tunnel is to be kept closed, is to be fitted near the opening. The opening is to be regarded as an opening in watertight bulkhead.

## Section 3

## Design Loads

### 3.1 Bottom shell

3.1.1 The design pressure 'p' [kN/m$^2$] on outer bottom is to be taken as

$p = 10\ T_1$ [kN/m$^2$]

$T_1$ to be obtained from Table 3.1.1.

**Table 3.1.1 : Values of $T_1$**

| Zone | $T_1$ |
|---|---|
| 1 | T+1.0 [m] for L > 60 [m]<br>T+0.6 [m] for L < 20 [m] |
| 2 | T+0.6 [m] |
| 3 | T+0.3 [m] |
| For intermediate values of L in Zone 1, $T_1$ to be linearly interpolated | |

In way of tanks, the design pressure is not to be taken less than internal pressure 'p' given in 3.2.1.

### 3.2 Watertight floors and girders

3.2.1 The design pressure 'p' on watertight floors and girders in double bottom tanks is to be taken as the greater of:

$p = 6.7\ h_p$ [kN/m$^2$]

$p = 10\ (h_s + 1)$ [kN/m$^2$]

where,

$h_p$ = vertical distance [m], from the load point to the top of air pipe.

$h_s$ = vertical distance [m], from the load point to top of the tank.

### 3.3 Inner bottom

3.3.1 The design pressure 'p' on the inner bottom is to be taken as the greater of that given in 3.2.1 and the following:

In way of cargo holds, the design pressure 'p' is not to be taken as less than:

$$p = 12.5\ \rho H \quad [kN/m^2]$$

where,

$\rho$ = cargo density [t/m$^3$] normally not to be taken as less than 0.7 [t/m$^3$]

H = height [m], to deck or top of hatchway coaming.

## Section 4

## Bottom and Inner Bottom Plating

### 4.1 Keel plate

4.1.1 The width of the plate keel is not to be less than (400+10L) [mm]. The thickness is to be 1 [mm] greater than that required for the adjacent bottom plating.

### 4.2 Bottom, bilge and inner bottom plating

4.2.1 The thickness of the bottom and inner bottom plating is to be not less than:

- for bottom plating

$t = (t_o+0.04L)\ \sqrt{k} + t_c$ [mm]

- for inner bottom plating.

$t = (t_o+0.03L)\ \sqrt{k} + t_c$ [mm] but not less than 6.0 [mm]

where,

$t_o$ = 4.0 [mm], in general.

= 6.0 [mm], for inner bottom plating where ceiling is not fitted.

= 4.0 [mm] for inner bottom plating where wooden ceiling of 50 [mm] thickness is fitted.

4.2.2 The bottom, bilge and innerbottom plating is also to comply with the requirements of buckling strength given in Ch.3, Sec.6.

4.2.3 For ships discharged by grabs and where no ceiling is fitted, the plating thickness 't' of the inner bottom and exposed parts of sloping bulkheads is not to be less than:

$$t_1 = 0.62\sqrt{s.k}\left(\frac{M_{GRAB}}{20}\right)^{0.25} + t_c\ [mm]$$

s = spacing of stiffeners [mm]

$M_{GRAB}$ = Mass of unladen grab [t]; $M_{GRAB}$ is not to be taken less than 7 tonnes

4.2.4 Where the inner bottom is subjected to wheel loads from cargo handling vehicles, the scantlings are also to comply with the requirements given in Ch.8, Sec.6.

## Section 5

## Single Bottom

### 5.1 Transverse framing

5.1.1 Plate floors of following scantlings are to be fitted at every frame

depth at centreline d = 40B [mm] in general

thickness of web, t = d/100 + 2.5 [mm]

Section modulus

$Z = 0.006\ s.l_f^2\ .\ T_1$ [cm$^3$] in cargo holds

$= 0.0072\ s.l_f^2\ .\ T_1$ [cm$^3$] in machinery and other spaces

where,

$l_f$ = span of floor, measured on the top of floor plate from side to side

= longitudinal bulkheads are provided the span, $l_f$ not to be taken less than 0.4B.

$T_1$ is as defined in 3.1.1.

The thickness of face plate is not to be less than 1/15 of the face width.

The top of floors, in general, is to be level from side to side. However, in ships having considerable rise of floor, the depth of web at 10 per cent of the span from ends, is not to be less than half the depth at centreline.

If the height of floors between engine girders is reduced in way of crankcase, the face plate area is to be suitably increased, however the reduced height is normally not to be less than 2/3 of 'd' as given above.

5.1.2 On all ships one centre girder is to be fitted and in addition side girders are to be fitted such that the spacing of girders does not exceed 3.0 [m]. The girders are to extend as far forward and aft as practicable and where they are cut at transverse bulkheads the longitudinal continuity is to be maintained. Where the bottom structure changes into a double bottom structure, the bottom girders are to extend at least 3 frame spaces into double bottom structures.

The scantlings of the centre girders and side girders are to be not less than that of the floors.

The thickness of face plates is not to be less than 1/15 of the face width.

5.1.3 In the after peak of single screw ships, the height of the floors is to be increased such that their upper edge is well above the stern tube.

5.1.4 Where single bottom in the cargo region is stiffened by transverse frames supported by longitudinal girders, the scantlings of the frames and longitudinal girders are to be determined in accordance with 6.2.3 and 5.2.3, 5.2.4 respectively.

### 5.2 Longitudinal framing

5.2.1 The spacing of bottom transverses is normally not to exceed 3.0 [m]. The bottom transverses are to be supported by primary girders or longitudinal bulkheads. Where the design does not incorporate a centreline bulkhead, at least a docking girder is to be provided. The scantlings of simple girders and transverses are to be obtained in accordance with 5.2.3. The scantlings of a complex girder system are to be based on a direct stress analysis.

5.2.2 The section modulus 'Z' of the bottom longitudinals is not to be less than:

$$Z = \frac{s\,p\,l^2}{12\,\sigma} + Z_c\ [\mathrm{cm}^3]$$

where,

p = applicable design pressure [kN/m$^2$], as given in 3.1.1.

$\sigma = (215 - 140\ f_B)/k$, max.160/k [N/mm$^2$]

within 0.4L amidships

= 160/k [N/mm$^2$] within 0.1L from ends.

Elsewhere σ may be obtained by linear interpolation.

5.2.3 The section modulus 'Z' of bottom girders is not to be less than:

$$Z = \frac{10^3\ b\,p\,S^2}{m\,\sigma} + Z_c\quad [\mathrm{cm}^3]$$

where,

m = 10 in general

p = applicable design pressure [kN/m$^2$], as given in 3.1.1.

$\sigma = (190 - 130\ f_B)/k$, max160/k [N/mm$^2$]

for continuous longitudinal girders within 0.4L amidships.

= 160/k [N/mm$^2$]

for longitudinal girder within 0.1L from ends and for transverse girders in general.

Elsewhere σ may be obtained by linear interpolation.

5.2.4 Tripping brackets are to be fitted in accordance with the requirements given in Ch.3, Sec.4.4.4.

## Section 6

## Double Bottom

### 6.1 General

6.1.1 Where double bottom spaces are used as tanks, the centre girder is to be watertight unless the double bottom is divided by watertight side girders or the tanks are narrow.

The depth 'd' of the centre girder is not to be less than:

d = 250 + 20B + 50T [mm],

with a minimum of 650 [mm].

In case of ships with considerable rise of floors the depth 'd' may have to be increased.

6.1.2 The thickness 't' of the bottom girders and floors is not to be less than

$t = (0.007d + 3)\ \sqrt{k}$ [mm].

6.1.3 The section modulus 'Z' of the stiffeners on girders and floors forming boundaries of double bottom tanks is not to be less than:

$$Z = \frac{s\,p\,l^2}{10\sigma} + Z_c\ [cm^3]$$

where,

p = design pressure [kN/m$^2$], as given in 3.2.1;

$\sigma = (210 - 130\ f_B)/k$, max. 160/k [N/mm$^2$]

for longitudinal stiffeners within 0.4L amidships

= 160/k [N/mm$^2$]

for longitudinal stiffeners within 0.1L from ends and for transverse or vertical stiffeners in general.

Between the regions specified above σ for longitudinal stiffeners may be obtained by linear interpolation.

Longitudinal stiffeners are to have end connections, other stiffeners may be sniped at ends provided the section modulus Z is increased by 40 per cent.

6.1.4 The longitudinal girders are to be satisfactorily stiffened against buckling in accordance with the requirements given in Ch.3, Sec.6.

### 6.2 Transverse framing

6.2.1 The side girders are normally to be fitted at a spacing not exceeding 4.0 [m] and are to be extended as far forward and aft as practicable. The girders are to be stiffened at every bracket floor by a vertical stiffener of depth same as that of reverse frame and thickness that of the girder.

6.2.2 Plate floors are to be fitted under bulkheads, pillars, thrust seating, boiler bearers and in way of change of depth of double bottom. In engine room, plate floors are to be fitted at every frame. Elsewhere plate floors are to be fitted at least every fifth frame, the spacing not exceeding 3.0 [m].

6.2.3 Where bracket floors are fitted the section modulus 'Z' of the bottom frames and reverse frames is not to be less than:

$$Z = \frac{s\,p\,l^2 k}{1.6} \times 10^{-3} + Z_c\ \ [cm^3]$$

where,

p = applicable design pressure [kN/m$^2$], as given in 3.1.1 and 3.3.1 for bottom frames and reverse frames respectively.

l = span of frames [m] measured between girder or brackets.

Where vertical struts according to 6.2.4 are fitted, the section modulus of bottom and reverse frames may be reduced by 35 per cent.

6.2.4 The cross sectional area 'A' of the struts is not to be less than

A = c . k . l . s . T . [cm$^2$]

where,

c = 7x10$^{-4}$ in way of ballast tanks

= 6x10$^{-4}$ elsewhere

l = actual span [m], without considering the strut.

The moment of inertia I of the struts is not to be less than:

I = 2.5 A . d$^2$ x 10$^{-6}$ [cm$^4$]

where,

d = depth of double bottom, [mm].

6.2.5 The bottom frames and reverse frames are to be attached to the centre girder and margin plate by means of brackets of same thickness as that of the plate floors. The breadth of the brackets is not to be less than 0.75 times the depth of the centre girder and the brackets are to be flanged 75 [mm] at their free edges.

### 6.3 Longitudinal framing

6.3.1 The side girders are normally to be fitted at a spacing not exceeding 5.0 [m] and are to be extended as far forward and aft as practicable.

6.3.2 The plate floors are to be fitted under bulkheads, pillars, thrust seating and boiler bearers. In engine room, plate floors are to be fitted at every second side frames. Additionally, under the main engine seatings, floors extending to the first side girder outside the engine seating, are to be fitted at intermediate frames. The spacing of floors is normally not to exceed 3.0 [m].

6.3.3 The plate floors are to be stiffened at every longitudinal by a vertical stiffener of depth same as that of the inner bottom longitudinal and thickness as

that of the floor. Between plate floors, transverse brackets are to be fitted at every frame at the margin plate and at a spacing not exceeding 1.25 [m] on either side of the centre girder. The thickness of brackets is to be same as that of the plate floors. The brackets are to extend upto the adjacent longitudinal and are to be flanged 75 [mm] at their free edges.

6.3.4 The section modulus 'Z' of the bottom and inner bottom longitudinals is not to be less than:

$$Z = \frac{s p l^2}{12\sigma} + Z_c \ [cm^3]$$

where,

p = applicable design pressure [kN/m$^2$], as given in 3.1.1 and 3.3.1 for bottom longitudinals and inner bottom longitudinals respectively;

l = span of longitudinals [m], measured between the plate floors

$\sigma$ = (210 - 140 $f_B$)/k [N/mm$^2$], maximum 160/k [N/mm$^2$] for bottom longitudinals within 0.4L amidships

= (210 - 100 $f_B$)/k [N/mm$^2$], maximum 160/k [N/mm$^2$] for inner bottom longitudinals within 0.4L amidships

$\sigma$ = 160/k [N/mm$^2$] within 0.1L from ends.

Between the regions specified above, $\sigma$ may be obtained by linear interpolation.

Where vertical struts according to 6.2.4 are fitted, the section modulus of the bottom and inner bottom longitudinals may be reduced by 35 per cent.

**Section 7**

**Engine Seatings**

**7.1 General**

7.1.1 It is recommended that the depth of the floors or double bottom in way of engine foundations be increased.

7.1.2 Sufficient fore and aft girders are to be arranged in way of the main machinery to effectively distribute its weight and to ensure adequate rigidity of the structure. The girders are generally to extend over the full length of the engine room and are to be suitably scarphed into the bottom structure beyond.

7.1.3 The scantlings of engine seatings are to be adequate to resist gravitational, thrust, torque, dynamic and vibratory forces which may be imposed on them. The recommendations given by the engine manufacturer are also to be taken into account.

7.1.4 Where the top plate of the engine seating is situated above the floors or the inner bottom, adequate transverse strength by means of brackets in line with the floors is to be ensured. In way of the recess for crankcase, brackets as large as practicable are to be fitted.

7.1.5 Lightening holes in engine foundations are to be kept as small as practicable and the edges are to be suitably reinforced.

**7.2 Recommended scantlings**

7.2.1 For engines of power less than 1500 kW and RPM greater than 1200, the scantlings of engine girder face plate, web and floors in way of engine seatings may be calculated as given below. Scantlings for other engines will be specially considered.

Top plate area; $A = 20 + 120 \left(\frac{P}{R}\right)$ [cm$^2$]

Thickness of top plate; $t_p = 0.1A + 14$ [mm]

Girder web thickness; $t_g = 0.043A + 7$ [mm]

Floor web thickness; $t_f = 0.02A + 6$ [mm]

where,

P = maximum power of the engine [kW]

R = rpm of engine at maximum power

## Chapter 7

## Side Structure

***Contents***



## Section 1

## General

### 1.1 Scope

1.1.1 The scantlings and arrangement of side structure as defined in Ch.1, Sec.2 and also those of sides of the superstructures are

to comply with the requirements of this Chapter.

### 1.2 Symbols

L, B, T, $C_b$, k as defined in Ch.1, Sec.2.

s = spacing of stiffeners, [mm].

l = span of stiffeners, [m].

b = spacing of girders, [m].

S = span of girders, [m].

$t_c$, $Z_c$ = corrosion additions to thickness and section modulus respectively, as given in Ch.3, Sec.2.1

$$f_D = \frac{Z_R}{Z_D}$$

$$f_B = \frac{Z_R}{Z_B}$$

$f_S = f_D$ for side shell area above neutral axis

$= f_B$ for side shell area below neutral axis

where,

$Z_R$ = Rule midship section modulus [$cm^3$] as required by Ch.4.

$Z_D$, $Z_B$ = Actual midship section moduli [$cm^3$] provided at deck and bottom respectively.

## Section 2

## Structural Arrangement and Details

### 2.1 General

2.1.1 The ship's side shell may be stiffened longitudinally or vertically.

2.1.2 Where the side shell is stiffened longitudinally, the continuity of the side longitudinals within a distance of 0.15D from bottom or from strength deck is to be maintained in accordance with Ch.3, Sec.5.1.1. The web frames are to be fitted in line with the bottom transverses or plate floors.

2.1.3 The position, shape and reinforcement of sea inlets or other openings in side shell are to be in accordance with the requirements of Ch.4.

2.1.4 In the case of superstructures exceeding 0.15L in length and ending within 0.5L amidships, the side plating of the superstructures is to be increased by 25 per cent in way of the break.

2.1.5 The thickness of the shell plating is to be increased locally by 50 per cent in way of sternframe, propeller brackets and rudder horn. For reinforcements in way of anchor pockets, hawse pipes etc. refer to Ch.13.

2.1.6 The weld connections are to comply with the requirements of Ch.14.

### 2.2 Sheer strake

2.2.1 The thickness of sheer strake as obtained from 4.1.1 is to be increased by 30 per cent on each side of a superstructure end bulkhead located within 0.5L amidships if the superstructure deck is a partial strength deck.

2.2.2 Where a rounded sheer strake is adopted, the radius in general, is not to be less than 15 times the plate thickness.

2.2.3 Bulwarks are generally not to be welded to the top of the sheer strake within 0.6L amidships.

2.2.4 Where the sheer strake extends above the deck stringer plate, the top edge of the sheer strake is to be kept free from notches and drainage openings if any, are to have smooth transition in the longitudinal direction.

## Section 3

## Design Loads

### 3.1 External pressure

3.1.1 The design pressure 'p' on side shell is to be taken as per Table 3.1.1.

### 3.2 Internal tank pressure

3.2.1 Where the side shell forms a boundary of a tank, the design pressure 'p' is to be taken as the greater of external pressure given by 3.1.1 and the internal tank pressure '$p_i$' given by 3.2.2.

3.2.2 The internal tank pressure '$p_i$' is to be taken as the greater of:

$$p_i = 10\,(h_s + 1) \quad [\mathrm{kN/m^2}], \text{ or}$$

$$= 6.7\,h_p \quad [\mathrm{kN/m^2}]$$

**Table 3.1.1**

| Zone | | Design pressure 'p' pkN/m$^2$] a) | |
|---|---|---|---|
| | | **For load points below the max. load waterline** | **For load points above the max. load waterline** |
| 1 | L ≥ 60 [m] | $10\,h_o + \left(15 - 5\dfrac{h_o}{T}\right)$ | 15 - 10 $h_o$ |
| | L ≤ 20 [m] b) | $10\,h_o + \left(9 - 3\dfrac{h_o}{T}\right)$ | 9 - 10 $h_o$ |
| 2 | | $10\,h_o + \left(9 - 3\dfrac{h_o}{T}\right)$ | 9 - 10 $h_o$ |
| 3 | | $10\,h_o + \left(5 - 2\dfrac{h_o}{T}\right)$ | 5 |

a) 'p' is not to be taken as less than 5 [kN/m$^2$]

b) For intermediate lengths (L) in Zone 1, the value of 'p' is to be linearly interpolated

$h_o$ = vertical distance [m], from the maximum load waterline to the loadpoint.

where,

$h_s$ = The vertical distance [m] from the load point to the top of tank

$h_p$ = vertical distance [m], from the load point to the top of air pipe.

For very large tanks which may be partially filled, sloshing pressures may have to be considered.

## Section 4

## Side Shell Plating and Stiffeners

### 4.1 Side shell plating

4.1.1 The thickness 't' of side shell is not to be less than:

$$t = (4 + 0.04L)\sqrt{k} + t_c \quad [\mathrm{mm}]$$

4.1.2 The side shell plating is also to comply with the requirements of buckling strength given in Ch.3, Sec.6.

4.1.3 The breadth of the sheer strake is not to be less than 100 D [mm].

Where the thickness of the strength deck plating is greater than that required for side plating, the sheer strake thickness is not to be less than the mean of the two values.

**4.2 Side shell longitudinals**

4.2.1 The section modulus 'Z' of side longitudinals is not to be less than

$$Z = \frac{spl^2}{12\sigma} + Z_c \ [cm^3]$$

where,

p = applicable design pressure at midpoint of the span [kN/m$^2$].

$\sigma$ = (215 - 145 $f_S$)/k, maximum 160/k [N/mm$^2$]

for side longitudinals at deck/bottom level within 0.4L amidships.

= 160/k [N/mm$^2$] at neutral axis within 0.4L amidships

= 160/k [N/mm$^2$] within 0.1L from ends and at the level of short superstructure decks.

Between the regions specified above `$\sigma$' may be obtained by linear interpolation.

**4.3 Main frames**

4.3.1 The section modulus 'Z' of the main frames bracketed at both ends as per 4.3.2 is not to be less than :

$$Z = \frac{spl^2k}{2400} + Z_c \ [cm^3] \ and$$

$$= 5.5\sqrt{Lk} \ [cm^3]$$

where,

p = applicable design pressure at midpoint of the span or mean of the pressures at two ends, whichever is greater, [kN/m$^2$].

4.3.2 Main frame brackets are to be as follows:

length of the bracket :

- for upper bracket : 70 l [mm]
- for lower bracket : 120 l [mm]

section modulus at end (including bracket) :

- for upper bracket : 1.7 Z [cm$^3$]
- for lower bracket : 2.0 Z [cm$^3$]

where,

Z = section modulus of main frame as given in 4.3.1

Where the free edge of the bracket exceeds 40 times the bracket thickness, the brackets are to be flanged. The flange width is to be at least 1/15 of the length of the free edge.

4.3.3 Brackets at ends of the main frame may be omitted provided the frame is carried through the supporting members and the section modulus obtained as per 4.3.1 is increased by 75 per cent.

**4.4 Superstructure frames**

4.4.1 Superstructure frames located between the collision bulkhead and the after peak bulkhead are to have section modulus 'Z' not less than:

$$Z = 0.005 \ s \ l^2 \ k \quad [cm^3]$$

4.4.2 The lower end of the superstructure frame is to be connected to the bracket or frame below or else it is to be bracketed above the deck. The upper end is to be bracketed to the deck beam or longitudinal.

**4.5 Peak frames**

4.5.1 Vertical peak frames forward of the collision bulkhead and aft of the after peak bulkhead are to have section modulus 'Z' not less than

$$Z = \frac{spl^2 k}{1600} + Z_c \ [cm^3] \text{ and}$$

$$= 5.5\sqrt{(L.k)} \ [cm^3]$$

where,

p = applicable design pressure [kN/m$^2$], as given in Sec.3.

4.5.2 Peak frames are to be bracketed at top and bottom and in way of side stringers, the connection is to provide adequate shear strength.

## Section 5

## Girders

**5.1 General**

5.1.1 Web frames are to be fitted in way of hatch end beams and deck transverses.

5.1.2 In the engine room, web frames are to be fitted at the forward and aft end of the engine and every 5th frame in general. The section modulus `Z' of the web frames and side stringers is to be obtained as per 5.1.5 taking 'b' as the mean of the web frame or stringer spacings respectively, on either side. The depth of the webs and stringers are not to be less than 2.5 times the depth of the ordinary frames.

Adequate deep beams are to be provided in line with the web frames.

5.1.3 In peak spaces, side stringers supporting vertical peak frames are normally to be fitted at every 2.6 [m]. The section modulus `Z' of the stringers is to be obtained as per Sec.5.1.5. The stringers are to be supported by web frames.

5.1.4 The scantlings of simple girders and web frames supporting frames and longitudinals are to be in accordance with 5.1.5. The scantlings of webs supporting fully effective side stringers are to based on point loadings and 'σ' values given in 5.1.5. The scantlings of the complex girder system are to be based on a direct stress analysis. The buckling strength of the cross ties, where fitted, is to comply with the requirements given in Ch.3, Sec.6.

5.1.5 The section modulus 'Z' of simple girders and web frames is not to be less than :

$$Z = \frac{b p S^2 . 10^3}{m\sigma} + Z_c \ [cm^3]$$

where,

p = applicable design pressure [kN/m$^2$], as given in Sec 3.

m = 12 for continuous longitudinal girders with end attachments in accordance with Ch.3, Sec.5.

= 10 for other girders with end attachments in accordance with Ch.3, Sec.5.

σ = (190 - 145 $f_S$)/k, max 160/k [N/mm$^2$], for continuous longitudinal girders within 0.4L amidships.

= 160/k [N/mm$^2$] for longitudinal girders within 0.1L from ends and for web frames in general.

Between the regions specified above, s may be obtained by linear interpolation.

5.1.6 The net cross sectional area 'A' of the girder web at ends is not to be less than

A = 0.06 Sbpk + 0.01 h $t_c$ [cm$^2$] for stringers and upper ends of the web frames.

= 0.08 Sbpk + 0.01 h $t_c$ [cm$^2$] for lower ends of the web frames.

where,

h = girder height [mm].

5.1.7 Tripping brackets are to be fitted in accordance with the requirements given in Ch.3, Sec.4.4.4.

# Chapter 8

# Deck Structure

***Contents***



## Section 1

## General

### 1.1 Scope

1.1.1 The scantlings and arrangement of deck structure as defined in Ch.1, Sec.2 are to comply with the requirements given in this Chapter.

### 1.2 Symbols

L,B,T,$C_b$,k as defined in Ch.1, Sec.2.

s = spacing of stiffeners, [mm].

l = span of stiffeners, [m].

b = spacing of girders, [m].

S = span of girders, [m].

$t_c$, $Z_c$ = corrosion additions to thickness and section modulus respectively as given in Ch.3, Sec.2.1.

$$f_D = \frac{Z_R}{Z_D}$$

where,

$Z_R$ = Rule midship section modulus [$cm^3$], as required by Ch.4.

$Z_D$ = actual midship section modulus [$cm^3$], provided at deck calculated as per Ch.4.

$$f_z = \frac{z}{z_n}$$

where,

$z_n$ = vertical distance [m], from the neutral axis of the hull girder to the strength deck, in general. For ships with continuous trunks refer to Ch.4, Sec.3.1.3.

z = vertical distance [m], from the neutral axis of the hull girder to the deck under consideration or to the free flange of the deck longitudinal or girder as relevant.

## Section 2

## Structural Arrangement and Details

### 2.1 General

2.1.1 In tankers, the deck is normally to be stiffened longitudinally in the cargo tank region, however, where L does not exceed 75 [m], consideration may be given to transversely stiffened decks.

2.1.2 The continuity of the deck longitudinals is to be maintained in accordance with Ch.3, Sec.5.1.1.

2.1.3 The deck within the line of hatchway openings is preferably to be stiffened transversely or alternatively the arrangements are to provide adequate transverse buckling strength. Where the deck outside the line of hatchway openings is framed longitudinally, the transverse beams or buckling stiffeners between the hatchways are to extend at least upto the second longitudinal from the hatch side or equivalent.

2.1.4 In ships with large hatch openings, the effective cross-sectional area of the deck between the hatchways is to be sufficient to withstand the transverse load acting on the ship's sides.

2.1.5 The weld connections are to comply with the requirements of Ch.14.

2.1.6 Hatchway corners are to be of streamlined, elliptical or circular shape as given in Ch.4. Where shapes other than the streamlined shape or equivalent are adopted, insert plates are to be fitted at the hatch corners in strength deck. The insert plates are to be 25 per cent thicker than the deck plating outside the line of hatchways and are to extend as shown in Fig.2.1.6. The butts of insert plates are to be well clear of those in coaming.

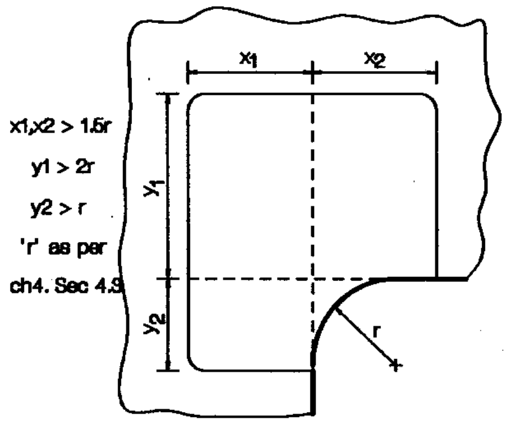



**Fig.2.1.6 : Extent of insert plate**

## Section 3

## Design Loads

### 3.1 Weather deck

3.1.1 The design pressure 'p' on exposed decks is to be taken as:

$p = H_1 - 10\ h_o$ [kN/m$^2$], minimum 5 [kN/m$^2$]

where,

$h_o$ = vertical distance [m], from the maximum load waterline to the deck.

$H_1$ = as given in Table 3.1.1.

| Table 3.1.1 | |
|---|---|
| **Zone** | **$H_1$** |
| 1 | 9 for $L \leq 20$ [m]<br>9 + 0.15 (L-20) for $20 < L < 60$<br>15 for $L \geq 60$ [m] |
| 2 | 9 |
| 3 | 5 |

3.1.2 For decks subjected to cargo loading the design pressure is to be taken as:

$p = 12.5\ q$ [kN/m$^2$]

where 'q' is deck cargo loading [t/m$^2$].

3.1.3 For weather decks forming crowns of tanks, the design pressure 'p' is to be taken as the greater of that given by 3.1.1 and 3.3.1.

### 3.2 Accommodation decks

3.2.1 The design pressure 'p' on accommodation decks is to be taken as :

$p = 4.5$ [kN/m$^2$]

3.2.2 For decks forming crowns of tanks the design pressure 'p' is to be taken as the greater of that given by 3.2.1 and 3.3.1.

### 3.3 Decks forming tank boundaries

3.3.1 The design pressure 'p' for decks forming the bottom or crown of a tank may be taken as the greater of the following:

$p = 6.7\ h_p$ [kN/m$^2$] or

$= 10\ (h_s + 1)$ [kN/m$^2$]

where,

$h_p$ = vertical distance [m], from the deck to the top of air pipe

$h_s$ = vertical distance [m], from the deck to the top of the tank.

## Section 4

## Deck Platings and Stiffeners

### 4.1 Deck platings

4.1.1 The thickness of the strength deck plating outside the line of hatchway openings is to be adequate to give the necessary hull section modulus and moment of inertia required by Ch.4.

4.1.2 The thickness 't' of deck platings is not to be less than:

$t = (t_o + 0.02L)\sqrt{k} + t_c$ [mm]

where,

$t_o$ = 5 for strength decks and forecastle decks

= 4.0 for other decks.

4.1.3 The strength deck plating outside the line of hatchways is also to comply with the requirements of buckling strength given in Ch.3, Sec.6.

4.1.4 In way of ends of bridges, poops and forecastles, the thickness of the strength deck stringer strake is to be increased by 20 per cent over four frame spaces fore and also aft of the end bulkheads.

**4.2 Deck stiffeners**

4.2.1 The section modulus 'Z' of deck longitudinals is not to be less than:

$$Z = \frac{s p l^2}{12\sigma} + Z_c \ [cm^3]$$

where,

p = applicable design pressure [kN/m$^2$] as given in Sec.3.

σ = (215 - 145$f_D$.$f_z$)/k, max. 160/k [N/mm$^2$] for strength deck and decks of long super-structures/deckhouses within 0.4L amidships.

= (225 - 145$f_D$.$f_z$)/k, max. 160/k [N/mm$^2$] for continuous decks below strength deck within 0.4L amidships.

= 160/k [N/mm$^2$] within 0.1L from ends and for short decks.

Elsewhere, σ may be obtained by linear interpolation.

The longitudinals are also to comply with the requirements of buckling strength given in Ch.3, Sec.6.

4.2.2 The section modulus 'Z' of transverse beams is not to be less than:

$$Z = \frac{spl^2k}{1600} + Z_c \ [cm^3]$$

where,

p = applicable design pressure [kN/m$^2$] as given in Sec.3.

## Section 5

## Deck Girders and Pillars

**5.1 Girders**

5.1.1 Deck girders and transverses are to be arranged in line with vertical members of scantlings sufficient to provide adequate support.

5.1.2 The scantlings of simple girders and transverses are to be in accordance with 5.1.3. The scantlings of a complex girder system are to be based on a direct stress analysis.

5.1.3 The section modulus 'Z' of deck girders is not to be less than:

$$Z = \frac{b p S^2 .10^3}{m\sigma} + Z_c \ [cm^3]$$

where,

p = applicable design pressure [kN/m$^2$] as given in Sec.3.

m = 12 for continuous longitudinal girders with end attachments in accordance with Ch.3.

= 10 for other girders with end attachments in accordance with Ch.3.

σ = (190 - 145$f_D f_z$)/k, max. 160/k [N/mm$^2$] for continuous longitudinal girders within 0.4L amidships.

= 160/k [N/mm$^2$] for longitudinal girders within 0.1L from ends and for transverse girders in general.

Elsewhere, `σ' may be obtained by linear interpolation.

5.1.4The net cross sectional area 'A' of the girder web at ends

is not to be less than:

$$A = 0.07 \ . \ S.b.p\ k + 0.01h\ t_c \ [cm^2]$$

where,

h = girder height [mm].

5.1.5 The girders are to be satisfactorily stiffened against buckling in accordance with the requirements given in Ch.3, Sec.6. Tripping brackets are to be fitted in accordance with the requirements given in Ch.3, Sec.4.4.4.

**5.2 Cantilevers**

5.2.1 The scantlings of cantilever beams and supporting frames will be specially considered.

**5.3 Pillars**

5.3.1 The scantlings of the pillars are to be in accordance with the requirements of Ch.3, Sec.6. Axial load, if any, from pillars above is to be added to the load from deck girders.

The minimum wall thickness 't' [mm], of the tubular pillars is not to be less than:

t = 4.5 + 0.015 d for d < 300 [mm]

= 0.03d for d ≥ 300 [mm]

where,

d = diameter of the pillar [mm].

5.3.2 Pillars are to be fitted in the same vertical line wherever possible, and arrangements are to be made

to effectively distribute the load at the heads and heels. Where pillars support eccentric loads, they are to be strengthened for the additional bending moments imposed upon them. Doubling or insert plates are generally to be fitted at the head and heel of hollow pillars.

5.3.3 The pillars are to have a bearing fit and are to be attached to the head and heel plates by continuous welding.

5.3.4 Where the heels of hold pillars are not directly above the intersection of plate floors and girders, partial floors and intercostal girders are to be fitted as necessary to support the pillars. Lightening holes or manholes are not to be cut in the floors and girders below the heels of pillars.

5.3.5 Inside tanks, hollow pillars are not to be used and strengthening at the heads and heels of pillars is not to be obtained by means of doubling plates. Where hydrostatic pressure may give rise to tensile stresses in the pillars, their sectional area 'A' is not to be less than

$$A = 0.07 \,.\, A_L.p \ [cm^2]$$

where,

p = design pressure as given in Sec.3, causing the tensile stress in pillar

$A_L$ = load area of deck [$m^2$], being supported by the pillar.

**Section 6**

**Decks for Wheel Loading**

### 6.1 General

6.1.1 Where it is proposed either to stow wheeled vehicles on the deck or to use wheeled vehicles for cargo handling, the requirements of this section are to be complied with in addition to those given in the preceding sections.

6.1.2 The requirements given below are based on the assumption that the considered element (Deck plating and/or stiffener) is subjected to one load area only, and that the element is continuous over several evenly spaced supports. The requirements for other loads and/or boundary conditions will be specially considered.

A "load area" is the tyre print area of individual wheels; for closely spaced wheels it may be taken as the enveloped area of the wheel group.

6.1.3 The details of wheel loadings are to be forwarded by the shipbuilder. These details are to include the proposed arrangement and dimensions of tyre prints, axle and wheel spacings, maximum axle load and tyre pressure.

### 6.2 Wheel loads

6.2.1 The pressure 'p' from the wheels on deck is to be taken as:

$$p = \frac{12.5W}{n.a.b} \, x \, 10^6 \ [kN/m^2]$$

– for stowed vehicles in sailing condition; and

$$p = \frac{W}{n.a.b}\left(9.81 + \frac{3}{\sqrt{W}}\right) 10^6 \ [kN/m^2]$$

– for cargo handling vehicles in harbour condition

where,

W = maximum axle load, [t]. For fork lift trucks, the total weight is to be taken as the axle load.

n = number of "load areas" per axle

a = extent [mm], of the load area parallel to the stiffener (see Fig. 6.2.1)

b = extent [mm], of the load area perpendicular to the stiffener (see Fig.6.2.1)

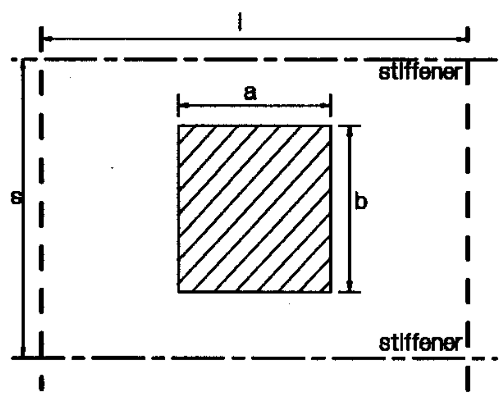



**Fig.6.2.1 : Plate panel and load area dimensions**

### 6.3 Deck plating

6.3.1 The thickness 't' of deck plating subjected to wheel loadings is not to be less than:

$$t = c_1 f_a \sqrt{\frac{c_2 b s p k.10^{-3}}{m}} + t_c \ [mm]$$

where,

$f_a$ = (1.1 - 0.25 s/l) for s ≤ l, however need not be taken as greater than 1.0

a,b,s,l = deck panel dimensions [mm] (see Fig.6.2.1)

$c_1$ = 0.137 in general for sailing conditions

= 0.127 in general for harbour conditions

= As per Table 6.3.1 for upper deck within 0.4L amidships.

**Table 6.3.1 : $c_1$ values for upper deck plating within 0.4L amidships**

| Framing system | Sailing conditions | Harbour conditions |
|---|---|---|
| Longitudinal | 0.145 | 0.130 |
| Transverse | 0.180 | 0.145 |

For upper deck plating between 0.4L amidships and 0.1L from ends, $c_1$ is to be varied linearly.

$$c_2 = 1.3 - \frac{4.2}{(a/s + 1.8)^2},$$

however, need not be taken as greater than 1.0

$$m = \frac{38}{(b/s)^2 - 4.7(b/s) + 6.5} \text{ for } b \leq s$$

**6.4 Deck stiffeners**

6.4.1 The section modulus 'Z' of deck beams and longitudinals subjected to wheel loadings is not to be less than:

$$Z = \frac{c_3.a.b.l.p\,10^{-6}}{m\sigma} + Z_c \ [cm^3]$$

where,

$c_3$ = (1.15 - 0.25 b/s) for b ≤ s, however need not be taken as greater than 1.0

$$m = \frac{r}{(a/l)^2 - 4.7\,a/l + 6.5}$$

r = 29 for continuous stiffeners supported at girders

= 38 when the continuous stiffeners can be considered as rigidly supported at girders against rotation.

σ = 160/k [N/mm$^2$] in general, for sailing conditions

= 180/k [N/mm$^2$] in general, for harbour conditions

= As per Table 6.4.1 for deck longitudinals within 0.4L amidships, but not exceeding the above general values.

For deck longitudinals between 0.4L amidships and 0.1L from ends, σ is to be varied linearly.

**Table 6.4.1 - σ Values for longitudinals within 0.4L amidships**

| Condition | [N/mm$^2$] |
|---|---|
| Sailing | (215 - 145$f_D.f_z$)/k |
| Harbour | (225 - 90 $f_D.f_z$)/k |

**6.5 Deck girders**

6.5.1 The scantlings of girders will be specially considered based on the most severe condition of moving or stowed vehicles. Also see Sec.6.1.3.

## Chapter 9

## Bulkheads

***Contents***



## Section 1

## General

### 1.1 Scope

1.1.1 The requirements of this chapter cover the arrangement and scantlings of watertight and deep tank bulkheads.

1.1.2 The requirements also cover the non-watertight bulkheads and shaft tunnels.

### 1.2 Symbols

L, B, T, $C_b$, k as defined in Ch.1, Sec.2.

s = spacing of stiffeners [mm]

l = span of stiffeners [m]

b = spacing of girders [m]

S = span of girders [m]

$t_c$, $Z_c$ = corrosion additions to thickness and section modulus respectively as given in Ch.3, Sec.2.1

$$f_D = \frac{Z_R}{Z_D}$$

$$f_D = \frac{Z_R}{Z_D}$$

where,

$Z_R$ = Rule midship section modulus [$cm^3$] as required by Ch.4.

$Z_D$, Z = Actual midship section moduli in [$cm^3$] provided at deck and bottom respectively calculated as per Ch.4.

$f_s$ =$f_D$ for side shell area above neutral axis

$f_s$ = $f_B$ for side shell area below neutral axis.

## Section 2

## Subdivision and Arrangement

### 2.1 Number of bulkheads

2.1.1 The following transverse watertight bulk-heads are to be fitted in all ships:

- A collision bulkhead;
- An aftpeak bulkhead;
- A bulkhead at each end of the machinery space.

In ships with machinery aft, the aftpeak bulkhead may form the aft boundary of the machinery space.

Additional transverse watertight bulkheads are to be fitted to ensure adequate transverse strength.

2.1.2 The ordinary transverse watertight bulk-heads in the holds should be spaced at reasonably uniform intervals. Where non-uniform spacing is unavoidable and the length of a hold is unusually large, the transverse strength of the ship is to be maintained by providing additional web frames, increased framing etc.

### 2.2 Position and height of bulkheads

2.2.1 he collision bulkhead is to be fitted at a distance of 0.04L to 0.1L from the F.P. Any recesses or steps in collision bulkheads are to fall within the limits.

2.2.2 Consideration will however be given to proposals for the collision bulkhead positioned aft of the limits given in 2.2.1, provided that the application is accompanied by calculations showing that with the

ship fully loaded to maximum draught on even keel, flooding of space forward of the collision bulkhead will not result in any part of the main deck becoming submerged, nor result in any unacceptable loss of stability.

2.2.3 All ships are to have an after peak bulkhead generally enclosing the sterntube and rudder trunk in a watertight compartment. In twin screw ships where the bossing ends forward of the after peak bulkhead, the sterntubes are to be enclosed in suitable watertight spaces.

2.2.4 The watertight bulkheads are in general to extend to the uppermost continuous deck.

2.2.5 For passenger ships the number and position of the bulkheads will normally be governed by the requirements of trim and stability in damaged condition given in Pt.5, Ch.4.

**2.3 Openings in watertight bulkheads and closing appliances**

2.3.1 Doors, manholes, permanent access openings or ventilation ducts are not to be cut in the collision bulkhead below the uppermost continuous deck.

2.3.2 Openings may be accepted in other watertight bulkheads provided the number and the size of openings is kept to a minimum compatible with the design and proper working of the ship. Where penetrations of watertight bulkheads are necessary for access, piping, ventilation, electrical cables, etc., arrangements are to be made to maintain the watertight integrity. In way of openings, suitable reinforcements are to be provided to ensure that the strength is at least equal to that of the unpierced bulkhead.

**2.4 Cofferdams**

2.4.1 Cofferdams are to be provided between the following spaces to separate them from each other:

- tanks for fuel oil or lubricating oil
- tanks for edible oil
- tanks for fresh water and feed water.

2.4.2 Tanks for lubricating oil are also to be separated by cofferdams from those carrying fuel oil. However, these cofferdams need not be fitted provided that the common boundaries have full penetration welds and the head of oil is generally not in excess of that in the adjacent lubricating oil tanks.

## Section 3

## Structural Arrangement and Details

**3.1 General**

3.1.1 Oil fuel or oil carried as cargo in the deep tanks is to have a flash point of 60°C and above in closed cup test. Where tanks are intended for other liquid cargoes of a special nature the scantlings and arrangements will be considered in relation to the nature of the cargo.

3.1.2 The continuity of bulkhead longitudinals within a distance of 0.15D from the bottom or the strength deck is to be maintained in accordance with Ch.3, Sec.5.1.1.

3.1.3 Carlings, girders or floors are to be fitted below the corrugated bulkheads at their supports. These supporting members are to be aligned to the face plate strips of the corrugations.

3.1.4 The weld connections are to comply with the requirements of Ch.16.

**3.2 Wash bulkheads**

3.2.1 A centreline wash bulkhead is to be fitted in peak spaces used as tanks, where the breadth of the tank exceeds 0.5B and also in deep tanks used for fuel oil extending from side to side.

3.2.2 The area of perforations is generally to be between 5% to 10% of the total area of bulkhead. The plating is to be suitably stiffened in way of the openings.

**3.3 Supporting bulkheads**

3.3.1 Bulkheads or parts thereof supporting deck structure are also to be designed as pillars. The permissible axial loads and buckling strength are to be calculated in accordance with Ch.3, Sec.6. In calculating sectional properties the width of attached plating is not to be taken in excess of 40 times the plate thickness. Also see Ch.8, Sec.5.1.1.

## Section 4

## Design Loads

**4.1 Watertight bulkhead loads**

4.1.1 The design pressure 'p', for ordinary watertight bulkheads is given by:

$$p = 10\,h \ \ [kN/m^2]$$

where,

h = the vertical distance [m] from the loadpoint to the uppermost continuous deck.

4.1.2 For bulkheads bounding cargo spaces intended to carry dry bulk cargoes, the design pressure 'p' is to be taken as the higher of that given in 4.1.1 and the pressure due to bulk cargo as given below:

$p = 12.5\ C\ \rho\ h_c$ [kN/m$^2$]

where,

$C = \mathrm{Sin}^2\alpha\ \mathrm{Tan}^2(45 - \delta/2) + \mathrm{Cos}^2\alpha$

$\alpha$ = angle made by the panel under consideration with the horizontal plane [deg.]

$\delta$ = angle of repose of cargo [deg.] not to be taken greater than the following

- 20° for light bulk cargo (e.g. coal, grain)
- 25° for bulk cement cargo
- 35° for heavy bulk cargo (e.g. ore)

$h_c$ = vertical distance [m], from the loadpoint to the mean horizontal plane corresponding to actual volume of cargo being considered

$\rho$ = density of cargo [t/m$^3$].

For vessels designed to carry heavy bulk cargoes which are also required to carry lighter cargoes, the pressure 'p' based on maximum mass of cargo to be carried in the hold and filled up to the top of hatch coaming would also require to be considered.

**4.2 Tank bulkhead loads**

4.2.1The design pressure 'p' for tank bulkheads are normally to be taken as the greater of

$p = 12.5\ h_s$ [kN/m$^2$]

$= 6.7\ h_p$ [kN/m$^2$]

$= 10\ (h_s + 1)$ [kN/m$^2$]

where,

$h_p$ = vertical distance [m] from the loadpoint to the top of the air pipe.

$h_s$ = vertical distance [m] from the loadpoint to the top of the tank or hatchway.

For very large tanks which may be partially filled, sloshing pressures may have to be considered.

4.2.2 The pressure 'p' on girder web panels in cargo tanks or ballast tanks is not to be taken as less than 20 [kN/m$^2$].

**4.3 Wash bulkheads loads**

4.3.1 The design pressure 'p' for wash bulk-heads may be taken as 50% of that for boundary bulkhead in the same location.

**Section 5**

**Plating and Stiffeners**

**5.1 Bulkhead plating**

5.1.1 The thickness 't' of the bulkhead plating is not to be less than the minimum thickness given in 5.1.2 nor less than

$$t = 15.8 s \sqrt{p/\sigma}\ \text{x}\ 10^{-3} + t_c\ \text{[mm]}$$

where,

p = applicable design pressure as given in Sec.4.

$\sigma$ = as per Table 5.1.1 for longitudinal bulkheads.

= 160/k for transverse tank bulkheads and collision bulkhead;

= 220/k for ordinary transverse watertight bulkheads.

= 190/k for transverse dry bulk cargo bulkheads

5.1.2 The minimum thickness requirement of the bulkhead plating is given by

$$t = (4.0 + 0.01L) + t_c\ \text{[mm]}$$

5.1.3 The plate thickness of corrugated bulkheads is not to be less than that required according to 5.1.1 and 5.1.2. The spacing 's' to be used in the calculation of the plating thickness is to be taken as the greater of 'b' or 'c' where 'b' and 'c' are indicated in Fig. 5.1.3.

For built up corrugation bulkheads, where the thickness of the flange and web are different, the thickness of the wider plating is also not to be less than :

**Table 5.1.1 : 'σ' values for longitudinal bulkhead plating**

| Region | Framing system | At neutral axis | At strength deck or at bottom | Between neutral axis and strength deck or bottom |
|---|---|---|---|---|
| 0.4L amidships | Vertical | 140/k | (175-130 $f_s$)/k max. 120/k | To be obtained by linear interpolation |
| | Longitudinal | 160/k | (185-105 $f_s$)/k max. 120/k | To be obtained by linear interpolation |
| Within 0.1L from ends | 160/k | 160/k | 160/k | |
| Elsewhere | to be obtained by linear interpolation between allowable values at regions specified above. | | | |

$$t = \sqrt{\frac{s^2.p}{2\sigma} - (t_a - t_c)^2} + t_c \ \ [mm]$$

where,

$t_a$ = thickness of adjacent plating [mm] not to be taken greater than t.

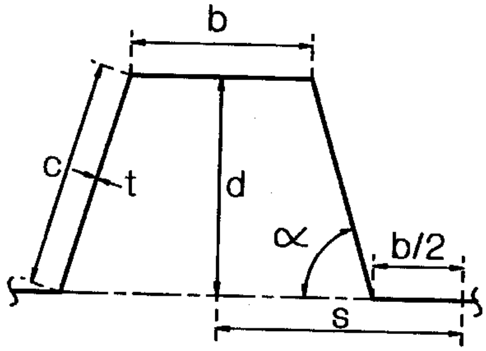



**Fig.5.1.3 : Corrugated bulkhead**

5.1.4 The longitudinal bulkhead plating within 0.1D from bottom or strength deck is also to comply with the requirements of buckling strength given in Ch.3, Sec.6.

5.1.5 In way of stern tubes, doubling plate of same thickness as the corresponding strake is to be fitted, or the strake thickness is to be increased by at least 60 per cent.

**5.2 Longitudinals**

5.2.1 The section modulus of continuous longitudinal stiffeners and corrugations is not to be less than:

$$Z = \frac{spl^2}{m\sigma} + Z_c \ \ [cm^3]$$

where,

p = applicable design pressure given in Sec.4.

m = 12

σ = (215 - 145 $f_s$)/k, max. 160/k [N/mm$^2$] at deck/bottom level within 0.4L amidships

= 160/k at neutral axis within 0.4L amidships

= 160/k for longitudinals within 0.1L from ends.

For longitudinals between the regions specified above σ may be obtained by linear interpolation.

5.2.2 The thickness of the web and flange is not to be less than the minimum plating thickness requirements stipulated in 5.1.2.

5.2.3 The rule section modulus of a corrugated bulkhead element is to be obtained according to 5.2.1 taking 's' as shown in Fig. 5.1.3.

5.2.4 The actual section modulus of a corrugated bulkhead element may be obtained in accordance with the following:

$$Z_{actual} = \frac{t.d(b + c/3)}{2000} \ [cm^3]$$

where, t,d,b and c [mm], are as shown in Fig. 5.1.3.

**5.3 Vertical and transverse stiffeners on tank bulkheads, collision bulkheads, dry bulk cargo bulkheads and wash bulkheads**

5.3.1 The section modulus of bulkhead stiffeners is not to be less than:

$$Z = \frac{spl^2}{m\sigma} + Z_c \ \ [cm^3]$$

where,

p = applicable design pressure [kN/m2] given in Sec.4.

m = 10 for transverse stiffeners and vertical stiffeners which may be considered fixed at both ends

= 7.5 for vertical stiffeners simply supported at one or both ends

= 10 for horizontal corrugation fixed at ends

= 13 for fixed upper end of vertical corrugation

= 20 for non-fixed upper end of vertical corrugation

= 10 for lower end of vertical corrugation

σ = 160/k for tank bulkhead and collision bulkhead

= 210/k for dry bulk cargo bulkheads.

5.3.2 The thickness of web and flange is to be as required in 5.1.2.

5.3.3 Actual section modulus of corrugations is to be obtained as per 5.2.4.

5.3.4 Brackets are normally to be fitted at the ends of non-continuous stiffeners. Where stiffeners are sniped at the ends, the thickness of the plating supported by the stiffeners is not to be less than:

$t = 0.0395 \sqrt{[(1 - 0.0005s)\ s.p.k]} + t_c$ [mm]

**5.4 Vertical and transverse stiffeners on ordinary watertight bulkheads**

5.4.1 The section modulus of bulkhead stiffeners is not be less than

$$Z = \frac{spl^2}{m\sigma}$$

where,

p = applicable design pressure given in Sec.4.

m = 16 for stiffeners fixed at both ends

= 12 for stiffeners fixed at one end (lower end in case of vertical stiffeners) and simply supported at the other end.

= 8 for stiffeners simply supported at both ends.

σ = 220/k

5.4.2 The thickness of web and flange is to be as required in 5.1.2. For sniped ends, the thickness of bulkhead plating is to be as per 5.3.4.

5.4.3 Actual section modulus of corrugations is to be obtained as per 5.2.4.

## Section 6

## Girders

### 6.1 General

6.1.1 Bulkhead stringers and deep transverses are to be arranged in line with other primary supporting structure to the adjoining deck, side shell and bottom so as to facilitate the formation of continuous ring structures. Otherwise equivalent scarphing arrangement is to be provided.

6.1.2 The section modulus requirement 'Z' of simple girders is not to be less than:

$$Z = \frac{b.p.S^2 \text{ x} 10^3}{m\sigma} + Z_c \ [cm^3]$$

where,

m = 12 for continuous longitudinal girders with end attachments in accordance with Ch.3, Sec.5.

= 10 for other girders with end attachments in accordance with Ch.3, Sec.5.

σ = (190 - 45$f_S$), max 160/k [N/mm$^2$], for continuous longitudinal girders within 0.4L amidships.

= 160/k [N/mm$^2$] for continuous longitudinal girders within 0.1L from ends and for vertical or transverse girders on tank and collision bulkheads.

= 210/k for vertical and transverse girders, in general.

For continuous longitudinal girders between the regions specified above, 'σ' may be obtained by linear interpolation.

6.1.3 The depth of the girders should not be less than 2.5 times the depth of the cutout (if any) for the passage of continuous stiffeners. The net cross sectional area 'A' of the girder web at ends is not to be less than

$$A = CkSbp + 0.01\ d_w\ t_c\ [cm^2]$$

where,

C = 0.060 for tank and collision bulkheads

C = 0.045 for other watertight bulkheads

$d_w$ = depth of web [mm].

However, for lower end of vertical girders value of C to be taken as 0.08 and 0.06 respectively.

6.1.4 Tripping brackets are to be fitted in accordance with the requirements given in Ch.3, Sec.4.

# Chapter 10

## Superstructures, Deckhouses and Bulwarks

***Contents***

*Section*



## Section 1

## General

### 1.1 Scope

1.1.1 The scantlings of the bulwarks and of the exposed bulkheads of the superstructures and deckhouses are to comply with the requirements of this chapter. The scantlings of the decks of the superstructures and deckhouses are to be in accordance with the requirements of Ch.8, and those of the sides of the superstructures are to be in accordance with the requirements of Ch.7.

### 1.2 Definitions

1.2.1 For definitions of the terms 'Superstructure' and 'Deckhouse' refer to Ch.1.

1.2.2 The lowest tier is normally the tier that is directly situated on the deck to which the rule depth 'D' is measured or on superstructures which are less than 1.8 [m] in height.

### 1.3 Symbols

1.3.1 L and k as defined in Ch.1, Sec.2.

s = spacing of stiffeners [mm].

l = span of stiffener [m].

## Section 2

## Scantlings

### 2.1 End bulkheads and exposed sides of deckhouses

2.1.1The thickness 't' of steel plating of the fronts, sides and aft ends of deckhouses and the front and aft ends of superstructures is not to be less than:

$t = (0.004\ s + 2.5)\sqrt{k}$ - for lowest tier

$= (0.004\ s + 1.5)\sqrt{k}$ - for upper tiers

2.1.2 The section modulus Z of stiffeners on fronts, sides and aft ends of deck houses and the front and aft ends of superstructures is not to be less than:

$Z = 3.6\ sl^2 \times 10^{-3}\ .\ k\ [cm^3]$ - for uppermost tier

I is not to be taken less than 2.0 [m].

When a multiple tier erection is fitted, the section modulus of stiffeners on lower tiers is to be increased at the rate of 15% per tier fitted above the tier under consideration.

2.1.3 The upper end of stiffeners on all erections are to be bracketed to the deck beams or longitudinals and the lower end is to be welded to the deck below.

### 2.2 Protected machinery casings

2.2.1 The thickness of plating is not to be less than:

$t = (0.003\ s + 1.5)\sqrt{k}$ [mm]

2.2.2 The section modulus 'Z' of stiffeners is not to be less than:

$Z = 0.003\ sl^2 \sqrt{k}\ [cm^3]$

where, l is not to be taken less than 2.0 [m].

2.2.3 Casings supporting one or more decks above are to be adequately strengthened.

## Section 3

## Structural Arrangement and Details

### 3.1 Structural continuity

3.1.1 Adequate transverse strength is to be provided to the deckhouses and superstructures by means of transverse bulkheads, girders and web frames.

3.1.2 The front and the after end bulkheads of large superstructures and deckhouses are to be effectively supported below by a transverse bulkhead or by a combination of partial bulkheads, girders and pillars. Similarly, the exposed sides of various tiers of

erections are to be supported by bulkheads, girders or carlings below.

3.1.3 All openings cut on the sides are to be substantially framed and have well rounded corners.

3.1.4 At the ends of superstructures, which have no set-in from the ships' side, the side plating is to extend beyond the ends of the superstructure, and is to be gradually reduced in height down to the sheer strake. The extended plating is to be adequately stiffened, particularly at its upper edge.

## Section 4

## Bulwarks and Guard Rails

### 4.1 General requirements

4.1.1 Bulwarks or guard rails are to be provided on the exposed parts of the freeboard and superstructure decks and also on all upper deck spaces normally accessible to crew and passengers. The height of the bulwarks or guard rails measured above the sheathing, if any, should not be less than the following:

For all passenger ships :

- For all Zones : 900 [mm]

For all other ships :

- For Zone 1 : 900 [mm]
- For Zone 2 : 600 [mm]
- For Zone 3 : 300 [mm].

Consideration will be given to cases where this height would interfere with the normal operation of the ship.

4.1.2 Bulwarks or guard rails as required by 4.1.1 may be dispensed with in way of hatch side coamings fitted with suitable handrails.

4.1.3 Where bulwarks on the weather portion of freeboard or superstructure decks form wells, provision is to be made for rapidly freeing the decks of water.

### 4.2 Bulwark construction

4.2.1 Bulwarks are to be stiffened at the upper edge by a strong rail section and supported by stays from the deck, spaced not more than 2.0 [m] apart. Where bulwarks are cut in way of a gangway or other openings, stays of increased strength are to be fitted at the ends of the openings.

Bulwark stays are to be supported by, or are to be in line with, suitable underdeck stiffening, which is to be connected by double continuous fillet welds in way of the bulwark stay connection.

Bulwarks are to be adequately strengthened in way of the eyeplates for cargo gear. In way of the mooring pipes, the plating is to be increased in thickness and also adequately stiffened.

4.2.2 Bulwarks are generally not to be welded to the top of the sheerstrake within 0.6L amidships and so arranged as to ensure their freedom from main structural stresses.

### 4.3 Bulwark scantlings

4.3.1 The thickness of the bulwark plating is not to be less than 4.0 [mm].

4.3.2 The section modulus 'Z' at the bottom of the bulwark stay is not to be less than:

$$Z = (33 + 0.44\ L)\ h^2\ s \quad [cm^3]$$

where,

h = height of the bulwark [m].

s = spacing of bulwark stays [m].

In the calculation of section modulus 'Z', only the material connected to the deck is to be included. The contribution from bulwark plating and/or stay flange may be considered depending upon the construction details.

### 4.4 Guard rails

4.4.1 The guard rails are to be supported by stanchions fitted not more than 3.0 [m] apart;

At least every third stanchion is to be supported by a bracket or stay.

4.4.2 Lengths of chain may be accepted in lieu of guard rails if they are fitted between two fixed stanchions and/or bulwarks.

4.4.3 The clear opening below the lowest course of the guard rails is not to exceed 230 [mm].

# Chapter 11

## Openings and Closing Appliances, Ventilators, Air Pipes and Discharges

***Contents***



## Section 1

## General

### 1.1 Scope

1.1.1 This Chapter applies to all ship types in general. Additional requirements pertaining to special ship types are given in Annex 4.

1.1.3 For the purpose of this section, weathertightness of hatch covers means that closing appliances do not permit entry of water into the ship which may prejudice the safety of the vessel under the navigational conditions envisaged.

## Section 2

## Hatch Coamings

### 2.1 Hatch coaming construction

2.1.1 Hatchside coamings are to extend to the lower edge of the deck beams. Side coamings not forming a part of continuous girders, are to extend two frame spaces beyond the hatch ends below the deck.

2.1.2 Hatch end coamings when not in line with the deck transverses are to extend below the deck, at least three longitudinal frame spaces beyond the side coaming.

2.1.3 Continuous hatchway coamings or coamings forming an effective part of the deck girder system are to be made from steel of same tensile strength as that of the deck plating.

2.1.4 If the junction of hatch coamings forms a sharp corner, the side and end coamings are to be extended in the form of tapered brackets in longitudinal and transverse directions respectively.

2.1.5 Extension brackets or rails arranged approximately in line with the cargo hatch side coamings and intended for the stowage of steel hatch covers are not to be welded to deckhouse, masthouse or to each other unless they form a part of the longitudinal strength members. The ends of supporting structures of hatch cover stowage rails are not to end abruptly and are to be tapered by suitable end brackets.

### 2.2 Coaming scantlings

2.2.1 The scantlings of hatch coaming plating and stiffeners are to be not less than that required for the adjacent deck.

2.2.2 Hatchway coamings 300 [mm] and above are to be stiffened in their upper edge.

Coaming stays are to be fitted at spacing of not more than 3.0 [m]. The stays are to end on stiffened plating. The coamings are to be satisfactorily stiffened against buckling.

## Section 3

## Hatch Covers

### 3.1 General

3.1.1 Hatch covers, where fitted, may be of the types a) to e) as described below.

**Hatch Cover Types :**

**'a'** : Steel plated cargo hatch covers stiffened by webs or stiffeners and secured by clamping devices. Weathertightness is to be ensured by means of gaskets. Hatch covers used for holds containing liquid cargoes are also included in this category.

**'b'** : Steel plated pontoon type cargo hatch covers with internal webs and stiffeners extending over the full width of the hatchway. Weather- tightness is to be achieved by tarpaulins.

**'c'** : Wood or steel hatch covers used in conjunction with the portable beams. Weathertightness to be obtained by tarpaulins.

**'d'** : Access hatch covers for cargo oil tanks and adjacent spaces. The hatch covers are to be of steel and gasketed.

**'e'** : Access hatch covers other than 'd'. The covers are to be of steel or wood and weathertight. Escape hatches are to be operable from both sides.

3.1.2 Materials for steel hatch covers are to satisfy the requirements of hull structural steel. Where other approved materials are used, equivalent strength and stiffness are to be provided.

**3.2 Design loads**

3.2.1 The design weather load on the weather deck hatchcovers is to be taken as:

$p = H_1 - 10\ h_o$ [kN/m$^2$], minimum 3 [kN/m$^2$]

where,

$h_o$ = Vertical distance [m] from the maximum load waterline to the top of hatch covers.

$H_1$ = as given in Table 3.2.1.

| Table 3.2.1 | |
|---|---|
| **Zone** | **$H_1$** |
| 1 | 9 for $L \le 20$ [m]<br>$9 + 0.15\ (L\text{-}20)$ for $20 < l < 60$<br>15 for $L \ge 60$ m |
| 2 | 0 |
| 3 | 5 |

3.2.2 For hatch covers subjected to cargo loading the design pressure is to be taken as:

$$p = 12.5\ q\ [\text{kN/m}^2]$$

where,

q = specified cargo loading [t/m$^2$] on the hatch cover.

3.2.3 The design internal pressure on hatch covers above tanks are to be determined as per the design pressure on deck structure given in Ch.8.

**3.3 Hatchcover plating**

3.3.1 The thickness of steel hatch cover plating is not to be less than:

$$t = 15.8 s \sqrt{p/\sigma}\ \text{x}10^{-3} + t_c\ \text{[mm], or}$$

3 [mm] whichever is greater

where,

p = design pressure as per 3.2

= 160/k [N/mm$^2$]

Hatch covers of G.I. sheet and other material will be specially considered.

3.3.2 The plating of hatch covers acting as compression flanges for the hatch cover stiffeners and girders is to be effectively stiffened against buckling.

In the middle part of the simply supported span the critical buckling stress $s_c$ is to be such that:

$\sigma_c \ge 1.15\ \sigma_b$ [N/mm$^2$]

where,

$\sigma_b$ = calculated bending stress in the compression flange corresponding to the design load as given in 3.2.

$\sigma_c$ = the critical buckling stress as per Ch.3, Sec.6.

**3.4 Stiffeners and girders**

3.4.1 The section modulus of the stiffeners and girders is not to be less than the following :

$$Z = \frac{6.25\, spl^2}{m}\ [\text{cm}^3]$$

where,

l = the member span between effective supports [m]

s = the member spacing [m]

m = 8 for members simply supported at ends

= 12 for members which can be considered as fixed at both ends.

The moment of inertia of stiffeners and girders is not to be less than:

$$I = 2.1\ Zl\ [\text{cm}^4]$$

For other materials the requirement will be specially considered.

3.4.2 For covers above cargo and ballast tanks, fillet welds on tank side are to be double continuous.

**3.5 Hatch cover edges**

3.5.1 The cover edges are to be adequately stiffened to withstand the forces imposed upon them during opening and closing of the hatches.

**3.6 Wooden hatch covers**

3.6.1 Wooden hatch cover planks are to have a finished thickness not less than 1/24th of the unsupported span, with a minimum of 20 [mm]. The planks of wood covers are to be connected at their underside by cross planks spaced not more than 1.5 [m].

3.6.2 The ends of all wooden hatch covers are to be protected by encircling with galvanized steel bands.

**3.7 Portable hatch beams**

3.7.1 The section modulus and the moment of inertia of the portable hatch beams stiffened at their upper and lower edges by continuous flat bars are to satisfy the requirements of 3.4.

3.7.2 Carriers or sockets, or other suitable arrangements are to be provided as means of the efficient fitting and securing of portable

hatch beams.

3.7.3 Sliding hatch beams are to be provided with an efficient device for locking them in their correct fore and aft positions when the hatchway is closed.

**3.8 Direct calculations**

3.8.1 Hatchcovers of special construction and arrangement e.g. covers designed and constructed as a grillage, covers supported along more than two opposite edges and covers supporting other covers, may require submission of direct strength calculation taking into account the arrangement of stiffeners and the supporting members.

**3.9 Hatch cover securing arrangement**

3.9.1 The gaskets and the securing arrangements are to be designed for the expected relative movement between cover and coaming or special devices are to be fitted to restrict such movement.

3.9.2 Securing arrangements together with suitable gasketting material are to ensure weathertightness of the covers to the satisfaction of the surveyors.

3.9.3 The gasket material is to be of satisfactory air, seawater and if necessary oil resistant quality. It is to be effectively secured along the edges of the cover in a manner as to ensure that the forces from the hatch covers or cargo stowed on top of the hatchcovers are transferred to the coaming or to the deck by direct contact without the load coaming on the gaskets. The sealing is to be achieved by relatively soft packing. The hatch coaming or steel parts on the adjacent covers in contact with the packing are to be well rounded where necessary.

A metallic contact is to be kept between the hatchcover and the hull to effect electrical earthing.

3.9.4 Where tarpaulins are fitted to make hatch covers weathertight. They are to be free from jute, and are to be waterproof and of ample strength. At least two layers of tarpaulins are to be provided and these are to be secured by battens and wedges or equivalent arrangements.

# Chapter 12

# Rudders

***Contents***



## Section 1

## General

### 1.1 Scope

1.1.1 The requirements of this Chapter apply to arrangement and scantlings of normal streamlined or plate rudders and their supporting structure. Rudders fitted with special features e.g. special profiles, fins, flaps, steering propellers etc. to increase the lift force will be specially considered.

### 1.2 Material

1.2.1 All materials used in the construction of the rudder are to be tested and approved in accordance with Annex 1.

1.2.2 Material grades for plates and sections for the rudder blade are to be selected as per Ch.2, Sec.1.3.

1.2.3 Bearing materials for bushings are to be stainless steel, bronze, white metal, synthetic material or lignum vitae. If stainless steel is proposed to be used for liners or bushes for the rudder stocks and pintles, the chemical composition is to be submitted for approval.

Hardness of the material of the bushing is to be at least 65 Brinell lower than that of the liner or the rudder stock or pintle.

Synthetic bush materials are to be of approved type. Arrangement is to be provided for adequate supply of sea-water to these bearings.

### 1.3 Testing

1.3.1 Bodies of the rudders are to be tested in accordance with the requirements given in Ch.15.

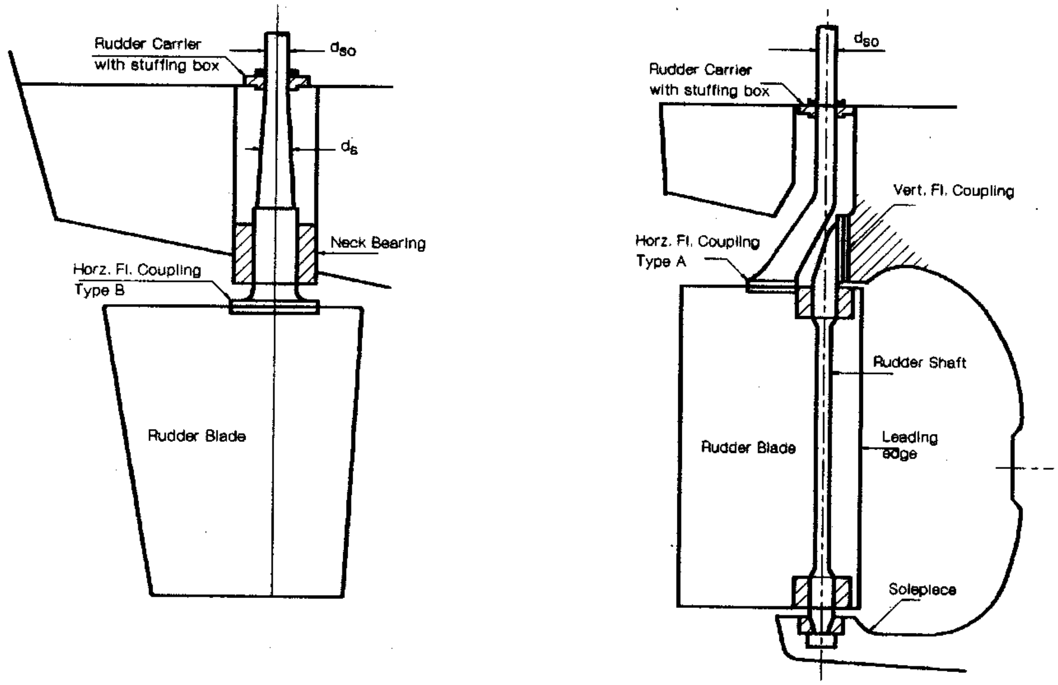
## Section 2

## Arrangement and Details

### 2.1 General

2.1.1 Various types of rudder arrangement are shown in Fig. 2.1.1; other combinations of couplings and bearings may, however, be proposed.

2.1.2 Effective means are to be provided for supporting the weight of the rudder. Where the support is provided by a carrier bearing attached to the rudder head, the structure in way of the bearing is to be adequately strengthened. The plating under all rudder head bearings or rudder carriers is to be increased in thickness.




SPADE RUDDER BALANCED RUDDER WITH SHAFT

**Fig.2.1.1 : Types of rudders**

2.1.3 All rudder bearings are to be accessible for measuring wear without lifting or unshipping the rudder.

2.1.4 Satisfactory arrangement is to be provided to prevent water from entering the steering gear compartment and lubricant from being washed away from the rudder carrier. A seal or stuffing box is to be fitted above the deepest load water line for this purpose unless the top of the rudder trunk (steering gear flat) is more than 300 [mm] above the deepest waterline in way trimmed condition. When the rudder carrier is fitted below the deepest load water line, two separate seals or stuffing boxes are to be provided.

2.1.5 Suitable arrangement is to be provided to prevent the rudder from lifting and accidental unshipping.

## Section 3

## Design Loads

### 3.1 Rudder force

3.1.1 The rudder force, upon which rudder scantlings are to be based, is to be determined from the following formula:

$$F_r = 132 \,.\, K_1 \,.\, K_2 \,.\, K_3 \,.\, A \,.\, V^2 \text{ [N]}$$

where,

$F_r$ = rudder force [N]

A = area of rudder blade [m$^2$]

V = maximum achievable ship speed (knots) in the lightest operating condition in which the rudder is fully immersed. V is not to be taken as less than 6 knots.

For astern condition, the maximum astern speed is to be used, but in no case less than:

$V_{astern} = 0.5V$

$K_1 = (\lambda + 2)/3$; with $\lambda$ not to be taken greater than 2.

$\lambda = b^2/A_t$; where b is the mean height of the rudder area [m] and $A_t$, the sum of rudder blade area and area of rudder post or rudder horn, if any, within the height b [m$^2$]

Mean breadth C [m] and mean height b [m] of rudder are calculated according to the co-ordinate system in Fig.3.1.1.

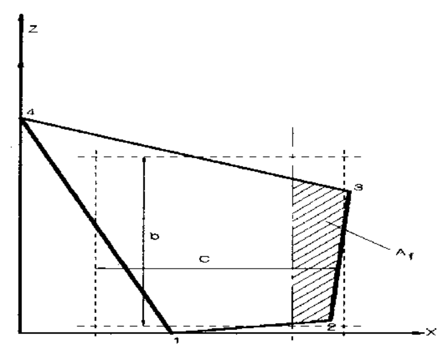



**Fig.3.1.1 : Rudder dimensions**

$K_2$ = Factor depending on the kind of rudder profile as per Table 3.1.1.

$K_3$ = 0.80 for rudders outside the propeller jet

= 1.15 for rudders behind a fixed propeller nozzle

= 1.0 otherwise.

**Table 3.1.1**

| Profile type | $K_2$ | |
|---|---|---|
| | ahead | astern |
| NACA:00 Gottingen profiles | 1.1 | 0.80 |
| Hollow profiles | 1.35 | 0.90 |
| Flat side profiles | 1.1 | 0.90 |

**3.2 Rudder torque**

3.2.1 The rudder torque on regular shaped rudders in both the ahead and astern conditions of travel is to be calculated as follows:

$$Q_r = F_r \cdot r \text{ [N-m]};$$

where,

$r = x_c - f$ [m]; but not to be taken less than 0.1C.

$x_c$ = the distance of the point of application of the design force Fr from the leading edge

= 0.33 C in ahead condition

= 0.66 C in astern condition.

C = Mean breadth of rudder area [m] See Fig. 3.1.1.

$f = C \cdot A_f/A$ where $A_f$ is the portion of the rudder blade area situated ahead of the centre line of the rudder stock.

3.2.2 In case of rudder blades with stepped contours the total rudder torque is to be obtained as follows:

$$Q_r = \Sigma Q_{ri} \quad \text{for } i = 1,2,3,.....$$

where,

$Q_{ri} = F_{ri} \cdot r_i$; individual torque component from each part Ai of the total rudder area.

$F_{ri} = F_r \cdot A_i/A$

$r_i = x_{ci}$ $f_i$; but not to be taken less than 0.1 $C_i$.

$x_{ci}$, $f_i$ and $C_i$ are to be taken as $x_c$, f and C as in 3.2.1 for each discrete part except that for those rudder parts immediately aft of rudder horn $x_{ci}$ is to be taken as $0.25C_i$ and $0.55C_i$ in ahead and astern conditions respectively.

**3.3 Bending moments, shear forces and reactions**

3.3.1 The bending moment (BM) and shear force (SF) distributions along the entire height of the rudder blade and rudder stock as well as the bearing reactions (R) may be obtained by direct calculation. The rudder is to be assumed as simply supported at the centres of the upper bearing and the neck bearing. In case of rudders supported by the sole piece or rudder horn the flexibility of the sole piece or rudder horn, and rudder and rudder stock is to be taken into consideration.

3.3.2 For common types of rudders , the following approximate values may be used:

- **For balanced rudders with heel support :-**

$$BM = \frac{F_r \cdot b}{8} \text{ [N-m]}$$

at mid-height of the rudder blade;

$$= \frac{F_r \cdot b}{7} \text{ [N-m]}$$

at centre of neck bearing.

$SF = 0.6\ F_r$ [N]

at top and bottom ends of the rudder blade;

$= 0.1\ F_r$ [N]

at mid-height of the rudder blade.

$R = 0.6\ F_r$ [N]

at the heel pintle bearing;

$= 0.7\ F_r$ [N]

at the neck bearing/stern pintle;

$= 0.1\ F_r$ [N]

at the upper bearing.

**- For spade rudders :-**

$$BM = \frac{F_r \cdot A_1 \cdot b_1}{A} \text{ [N-m]}$$

at any cross section below and including the neck bearing.

$$SF = \frac{F_r \cdot A_1}{A} \text{ [N]}$$

at any cross section upto the centre of the neck bearing.

$$R = \frac{b_2 + b_3}{b_3} \cdot F_r \text{ [N-m]}$$

at the neck bearing;

$$= \frac{b_2}{b_3} \cdot F_r \text{ [N]}$$

at upper bearing;

where,

$A_1$ = rudder area below the cross section under consideration;

$b_1$ = vertical distance from the centroid of $A_1$ to the cross section;

$b_2$ = vertical distance from the centroid of rudder area A to the centre of the neck bearing, and

$b_3$ = vertical distance between the centres of the upper and lower bearings.

3.3.3 At upper bearings the bending moments are to be taken as zero and between the upper bearing and the neck bearing the bending moments may be varied linearly.

## Section 4

## Rudder Blades

### 4.1 Construction details

4.1.1 Care is to be taken to avoid notch effects and to maintain continuity of strength around cut-outs and openings in the side plating. The plating thickness is to be increased suitably and corners are to be well rounded and ground smooth.

4.1.2 Side plating and vertical webs transmitting the torque are to be welded to the coupling flange by full penetration welds.

4.1.3 In general, welds between plates and heavy pieces are to be made as full penetration welds. Where back welding is not practicable, welding is to be performed against backing bar or equivalent.

4.1.4 Webs are to be connected to the side plating in accordance with Ch.14. Where fillet welding is not practicable, side plating is to be connected by means of slot welding to flat bars welded to the webs. Normally slots of length 75 [mm], breadth at least twice the side plating thickness and spaced 200 [mm] centre to centre will be accepted. The ends of the slots are to be well rounded. In areas subjected to large bending stresses, horizontal slots may require to be replaced by continuous weld.

4.1.5 Arrangement is to be provided to drain the rudders completely. Drain plugs are to be provided with efficient packing.

4.1.6 Internal surfaces of rudders are to be efficiently coated for corrosion resistance after completion of fabrication and testing. Where it is intended to fill the rudder with plastic foam, details of the foam material are to be submitted.

### 4.2 Double plated rudders

4.2.1 Thickness 't' of the rudder side, top and bottom plating is not to be less than:

$$t = 5.5 s f_a \sqrt{k\left(T + \frac{F_r}{A}10^{-4}\right)}\ \ 10^{-3} + 2.5\ [mm]$$

where,

$$f_a = \sqrt{1.1 - 0.5(s/1000.l)^2}\ ;\ \max.1.00$$

s = the smaller of the distances between the horizontal or the vertical web plates [mm].

l = the larger of the distances between the horizontal or the vertical web plates [m].

The thickness 't' is however not to be less than the minimum side shell thickness as per Pt.3, Ch.7.

For nose plates the thickness is to be increased to 1.25 t.

4.2.2 The thickness of the vertical and horizontal webs is not to be less than 70 per cent of the requirement given in 4.2.1 with a minimum of 7 [mm].

4.2.3 The thickness of side plating and vertical webs forming the main piece may have to be increased locally in way of the coupling and cut-outs or openings, if any.

### 4.3 Single plated rudders

4.3.1 Rudder blade thickness is not to be less than:

$t = 1.5 . y. V \sqrt{k}. 10^{-3} + 2.5$ [mm]

where y is the spacing of horizontal arms, [mm]; and V, the speed in knots as per 3.1.1.

4.3.2 Rudder blade is to be stiffened by horizontal arms spaced not more than 1000 [mm] apart. The arms are to be efficiently attached to the main piece. The thickness of the arms is not to be less than the blade thickness. The section modulus of the arms in way of main piece is not to be less than:

$Z = 0.5 . y . x^2 V^2 k. 10^{-3}$ [$cm^3$]

where,

x is the distance from the centre line of the stock to the after end of the rudder [m].

4.3.3 The diameter of the mainpiece at top end is not to be less than that of the lower rudder stock, and it may be gradually reduced towards lower end.

## Section 5

## Rudder Stock and Pintles

### 5.1 Rudder stock

5.1.1 Diameter of the rudder stocks, when obtained by direct calculation, are normally to give an equivalent stress se not exceeding 138 [$N/mm^2$] i.e.

$$\sigma_e = \sqrt{\sigma^2 + 3\tau_t^2} \le 138\ [N/mm^2]$$

where,

σ is the bending stress [$N/mm^2$],

$\tau_t$ is the torsional shear stress [N/mm$^2$].

This requirement is regardless of the liners; and both ahead and astern conditions are to be considered.

5.1.2 The diameter of the rudder stock at and above rudder carrier is given by

$$d_u = 4.0\sqrt[3]{(Q_r)} \text{ [mm]}$$

5.1.3 The diameter of rudder stock at any other cross section is given by

$$d_s = d_u \cdot \sqrt[6]{\left[1 + \frac{4}{3} \cdot \frac{BM}{Q_r^2}^2\right]} \text{ [mm]}$$

where BM is the bending moment at the cross section under consideration obtained as per 3.3.

5.1.4 The diameter of the rudder stock at neck bearing is to be maintained to a point as far as practicable above the top of the neck bearing and may subsequently be tapered to that required at the rudder carrier. The length of the taper is to be at least three times the reduction in diameter. Particular care is to be taken to avoid the formation of a notch at the upper end of the taper.

5.1.5 Sudden changes of section or sharp corners in way of the rudder coupling, jumping collars and shoulders for rudder carriers are to be avoided. Jumping collars are not to be welded to the rudder stock. Keyways in the rudder stock are to have rounded ends and the corners at the base of the keyway are to be adequately radiused.

**5.2 Pintles and bearings**

5.2.1 The diameter $d_p$ of the pintles, measured on the inside of liners where fitted, is not to be less than:

$$d_p = 0.35 \sqrt{R} \text{ [mm]}$$

where,

R = Reaction force [N] at the pintle bearing, obtained as per Sec.3.3.

5.2.2 Pintles are to have a conical attachment to the gudgeons and the taper on diameter is generally to range between 1:8 to 1:12. The slugging nut is to be efficiently secured. An effective sealing against sea water is to be provided at both ends of the cone.

5.2.3 The length of pintle housing in the gudgeon is not to be less than the pintle diameter $d_p$. The thickness of the pintle housing is not to be less than 0.25 $d_p$.

5.2.4 Where liners are fitted to pintles, they are to be shrunk on or otherwise efficiently secured. If liners are to be shrunk on, the shrinkage allowance is to be indicated on the plans. Where liners are formed by stainless steel weld deposit, the pintles are to be of weldable quality steel, and details of the procedure are to be submitted. Bushing is to be effectively secured against movement.

5.2.5 Pintle clearances are normally to be as given in Table 5.2.5.

Attention is to be paid to the manufacturer's recommendations particularly where bush material requires pre-soaking.

**Table 5.2.5 : Pintle Clearances**

| | |
|---|---|
| - For metal bearing material | 0.001 $d_p$ + 1.0 [mm] |
| - For synthetic bearing material | To be specially determined considering the swelling and thermal expansion properties of the material, but not less than 1.5 [mm]. |

5.2.6 The bearing pressure 'p', due to reaction 'R' on projected bearing area is not to exceed the values given in Table 5.2.6. For the purpose of this calculation, the bearing length is not to be taken greater than 1.2 times the rudder stock or pintle diameter measured outside of liners, if fitted. Higher values than given in the table may be taken on verification by tests.

**Table 5.2.6 : Bearing pressure**

| Bearing Materials | P [N/mm$^2$] |
|---|---|
| Steel or bronze against lignum vitae | 2.5 |
| Steels against white metal, oil lubricated | 4.5 |
| Steel against synthetic material with hardness between 60 and 70 shore D(1) | 5.5 |
| Steel against stainless steel, bronze and hot pressed bronze-graphite materials | 7.0 |

Note : (1) Indentation hardness test at 23°C and with 50% moisture, according to a recognised standard. Synthetic bearing materials to be of approved type.

## Section 6

## Rudder Couplings

### 6.1 Horizontal bolted couplings

6.1.1 The diameter of the coupling bolts is not to be less than:

$$d_b = 0.62 \left[\frac{d_s^3\, k_b}{ne_m\, k_s}\right]^{1/2} \ [mm]$$

where,

$d_s$ = Rule stock diameter [mm] in way of the coupling flange;

$k_s$ = material factor for the rudder stock material;

$k_b$ = material factor for the bolt material

n = total number of bolts;

$e_m$ = mean distance of the bolt axis from the centre of the bolt system [mm].

6.1.2 Coupling bolts are to be fitted bolts and a minimum of six (6) bolts are to be provided. Their nuts are to be effectively locked.

6.1.3 Mean distance em from the centre of the bolts to the centre of the bolt system is not to be less than 0.9 $d_s$ [mm]. In addition, where the coupling is subjected to bending stress the mean athwartship distance from the centre of bolts to the longitudinal centreline of the coupling is not to be less than 0.6 $d_s$ [mm].

6.1.4 The thickness of coupling flanges is not to be less than the diameter of the coupling bolts.

6.1.5 The width of material outside the bolt holes is not to be less than 0.67 $d_b$ [mm].

### 6.2 Vertical flange couplings

6.2.1 The diameter of the coupling bolts is not to be less than:

$$d_b = 0.81 \left[\frac{d_s^3\, k_b}{n\, k_s}\right]^{1/2} \ [mm]$$

where,

$d_s$ = Rule stock diameter [mm] in way of the coupling flange

$k_s$ = material factor for the rudder stock material;

$k_b$ = material factor for the bolt material

n = total number of bolts, not to be less than 8.

6.2.2 The first moment of area of the bolts about the centre of the coupling to be not less than:

$$m = 0.00043\ d_s^3\ \ [cm^3]$$

6.2.3 The thickness of the coupling flanges must be at least equal to the bolt diameter; and the width of the flange material outside the bolt holes must be greater than or equal to 0.67 $d_b$.

# Chapter 13

# Anchoring and Mooring Equipment

***Contents***



## Section 1

## General

### 1.1 Introduction

These requirements are based on maximum current of 8 [km/hr], water depth of 5-7 [m] and good holding ground conditions. Where environmental conditions are different from those specified above, the anchoring and mooring equipment would be specially considered based on actual conditions.

1.1.2 For tugs intended for towing other ships, having onboard suitable lines for the same purpose, the requirement of towline may be waived with written concurrence from the Owners.

1.1.3 The requirements for anchoring and mooring equipment specified in this Section are intended for vessels operating purely in Inland Waterways.

### 1.2 Documentation

1.2.1 The arrangement of anchoring and mooring equipment and Equipment calculations are to be submitted for information.

1.2.2 Following details of the proposed equipment are to be submitted for approval:-

1) Number, weight, type and design of anchors.
2) Length, diameter, grade and type of chain cables.
3) Type and breaking load of steel and fibre ropes.

### 1.3 Symbols

1.3.1 L,B,T as defined in Ch.1, Sec.2.

## Section 2

## Structural Arrangement for Anchoring Equipment

### 2.1 General

2.1.1 The fore end of the vessel is to be arranged in such a way that the anchors do not protrude beyond the side shell. The anchors are normally to be housed in hawse pipes and anchor pockets of adequate size, scantlings and suitable form to prevent movement of anchor and chain due to wave action.

The arrangements are to provide an easy lead of chain cable from windlass to the anchors. Upon release of the brake, the anchors are to immediately start falling by their own weight. Substantial chafing lips are to be provided at shell and deck. These are to have sufficiently large, radiused faces to minimise the probability of cable links being subjected to large bending stresses. Alternatively, roller fairleads of suitable design may be fitted.

Alternative arrangements for housing of anchors will be specially considered.

2.1.2 The shell plating and framing in way of the hawse pipes are to be reinforced as necessary.

2.1.3 When two chain cables are used, the chain locker is to be divided into two compartments, each capable of housing the full length of one line. The chain locker is to have adequate capacity and depth to provide an easy direct lead for the cable into the chain pipes, when the cable is fully stowed. The chain pipes are to be of suitable size and provided with chafing lips. The chain lockers boundaries are to be watertight. Provisions are to be made to minimize the ingress of water to the chain locker in bad weather. Adequate arrangement for drainage of chain lockers is to be provided.

Provisions are to be made for securing the inboard ends of the chains to the structure. The strength of this attachment should be between 15 per cent to 30 per cent of the breaking strength of the chain cable. It is recommended that suitable arrangements be provided so that in an emergency the chain can be

readily made to slip from an accessible position outside the chain locker.

2.1.4 The windlass and chain stoppers are to be efficiently bedded and secured to deck. The thickness of deck plating is to be increased in way of the windlass and chain stoppers and adequate stiffening underneath is to be provided.

2.1.5 Hawse pipe scantlings

.1 The gross thickness of the hawse pipes is not to be less than:

— for $t_0 < 10$ mm; $t = \min(t_0 + 2; 10)$

— for $t_0 \geq 10$ mm; $t = t_0$

*Where* $t_0$ = gross thickness of adjacent shell plating [mm]

## Section 3

## Anchors

### 3.1 General

3.1.1 Anchors are to be of an approved design and of a type suitable for the intended service. Cast iron anchors are not permitted to be used.

3.1.2 The mass of each bower anchor as required in this Section is for anchors of equal mass. The masses of individual anchors may vary by ± 7 per cent of the calculated masses, provided that the total mass of the anchors is not less than would have been required for anchors of equal mass.

3.1.3 Where the maximum current expected in service differs considerably from 8 [km/hr], the anchor weight is to be suitably modified. Where the maximum current expected in service considerably exceeds 8 [km/hr] or 4.32 [knots], the calculated anchor mass is to be increased by the factor:

$$\left(\frac{\text{Curent speed in km/hr}}{8}\right)^{1.875}$$

$$\left(\frac{\text{Curent speed in knots}}{4.32}\right)^{1.875}$$

Where the maximum current expected in service is less than 8 [km/hr] or 4.32 [knots], the calculated anchor mass may be reduced by the factor:

$$\left(\frac{\text{Current speed in km/hr}}{8}\right)^{0.5}$$

$$\left(\frac{\text{Current speed in knots}}{4.32}\right)^{0.5}$$

3.1.4 The mass of the head, including pins and fittings, of an ordinary stockless anchor is not to be less than 60 per cent of the total mass of the anchor.

3.1.5 The mass 'ex stock' of stocked bower or stream anchors is not to be less than 80 per cent of the tabular mass of ordinary stockless bower anchors. The mass of the stock is to be 25 per cent of the total mass of the anchor including the shackle etc. but excluding the stock.

3.1.6 When anchors of a design approved for the designation 'High Holding Power' are used as bower anchors, the mass of each such anchor may be reduced as indicated in 3.5.1. Approval of other HHP anchors will be specially considered.

3.1.7 Anchor shackles are to be of a design and material suitable to the service for which the anchor is intended.

### 3.2 Manufacture and testing

3.2.1 Anchors and anchor shackles are to be manufactured and tested in accordance with the requirements of Annex 1.

### 3.3 Bow Anchors

3.3.1 Cargo Vessels

3.3.1.1 The total mass 'P' of the bow anchors of cargo carriers is to be calculated in accordance with the following:

$$P = kBT$$

Where, $k = c\left(\frac{Loa}{8B}\right)^{0.5}$

$L_{oa}$ is the length overall

c is a coefficient defined in Table 3.3.1.1

For pushed barges, k = c

The breath B, to be considered for the application of these requirements to multi-hull vessels is to be determined using the following formula:

$$B = \sum Bi$$

where Bi is the individual breadth of each hull.

**Table 3.3.1.1 : Value of Coefficient 'c'**

| Deadweight [tonnes] | c |
|---|---|
| ≤ 400 | 45 |
| > 400 ≤ 650 | 55 |
| > 650 ≤ 1000 | 65 |
| > 1000 | 70 |

3.3.2 Passenger vessels and vessels not intended for carriage of goods (e.g. launches)

3.3.2.1 Passenger vessels and vessels not intended for the carriage of goods, apart from pushers, are to be fitted with bow anchors whose total mass 'P' is obtained from the formula in 3.3.1.1 where:

k: Coefficient corresponding to 3.3.1.1 but, where, in order to obtain the value of the empirical coefficient c, the maximum displacement, in $m^3$, is to be taken instead of the deadweight tonnage.

3.3.3 Increased bower anchor mass

3.3.3.1 For passenger vessels, and for vessels having a large windage area (such as container vessels), the bow anchor mass is to be increased as follows:

$$P_i = P + 4\,A_f$$

where, $A_f$ is the Transverse profile view (windage area) of the hull above waterline at the draught T, in $m^2$.

For calculating the area $A_f$, all superstructures, deckhouses and cargoes (e.g. containers) having a breadth greater than B/4 are to be taken into account.

Parts of windscreens or bulwarks which are more than 0.8 [m] in height are to be regarded as parts of houses when determining $A_f$.

**3.4 Stern Anchors**

3.4.1 Stern anchors are to be fitted in compliance with the requirements of 3.4.4 to 3.4.8.

3.4.2 The requirement for stern anchors may be specially considered in certain cases depending on specified operating conditions regarding, for instance, current speed or vessel positioning.

3.4.3 Self-propelled vessels are to be fitted with stern anchors whose total weight is equal to 25% of the mass P calculated in accordance with 3.3.

3.4.4 Vessels whose maximum length $L_{oa}$ exceeds 86 [m] are to, however, be fitted with stern anchors whose total mass is equal to 50% of the mass P or Pi calculated in accordance with 3.3.

3.4.5 Pushers

Vessels intended to propel rigid convoys not more than 86 [m] in length are to be fitted with stern anchors whose total mass is equal to 25% of the maximum mass P calculated in accordance with 3.3.1.1 for the largest formation considered as a nautical unit.

3.4.6 Vessels intended to propel downstream rigid convoys that are longer than 86 [m] are to be fitted with stern anchors whose total mass equals 50% of the greatest mass P calculated in accordance with 4.3.1.1 for the largest formation considered as a nautical unit.

3.4.7 Stern anchors requirements are not applicable to the following:

- vessels for which the calculated stern anchor mass will be less than 150 [kg]
- vessels intended to operate on reservoirs, lakes;
- pushed barges and pontoons;
- tugs intended for towing operations only.

**3.5 Mass Reduction**

3.5.1 The anchor masses calculated in accordance with 3.3 and 3.4 may be reduced for certain special anchors, such as high holding power anchors. Examples of such anchors and the permissible mass reduction is specified in Table 3.5.1

**Table 3.5.1 : High Holding Power Anchors**

| Anchor Type | Mass Reduction |
|---|---|
| HA-DU | 30% |
| D'Hone Special | 30% |
| Pool 1 (hol) | 35% |
| Pool 2 (massief) | 40% |
| De Biesbosch-Danforth | 50% |
| Vicinay-Danforth | 50% |
| Vicinay AC 14 | 25% |
| Vicinay Typ 1 | 45% |
| Vicinay Typ 2 | 45% |
| Vicinay Typ 3 | 40% |
| Stockes | 35% |
| D'Hone-Danforth | 50% |
| Schmitt high holding anchor | 40% |
| SHI high holding anchor, type ST (standard) | 30% |
| SHI high holding anchor, type FB (fully balanced) | 30% |
| Klinsmann anchor | 30% |
| HA-DU-POWER anchor | 50% |

**3.6 Number of Anchors**

3.6.1 The total mass P specified for bow anchors may be distributed among one or two anchors. It may be reduced by 15% where the vessel is equipped with only a single bow anchor.

3.6.2 The required total weight of stern anchors

for pushers and vessels whose maximum length exceeds 86 [m] may be distributed between one or two anchors.

3.6.3 The mass of the lightest anchor is not to be less than 45% of that total mass.

## Section 4

## Anchor Chain Cables

### 4.1 General

4.1.1 Chain cables may be either short link or stud link and of mild steel or special quality steel meeting the requirements of breaking strength and the length as given in 4.3. The required chain diameter is to be obtained by using tables of chain breaking strength given in Annex 1 Ch.10.

4.1.2 In conjunction with HHP anchors, only Grade CC2 or ISO Grade 40 chain cable is to be used, however, for HHP anchors having a mass of 300 [kg] or less, Grade CC1 chain cable may be accepted provided the diameter of Grade CC1 cable required is increased by ten per cent.

4.1.3 When desired by the Owners, steel wire ropes may be used instead of chain cables. Steel wire ropes are to have a breaking strength not less than that required for chain cables and their length is to be not less than 20 per cent in excess of the length required for chain cable.

In such cases it is recommended that a short length of chain or a swivel is fitted between the anchor and the wire rope, having a length equal at least the distance from the anchor in the stowed position to the winch.

4.1.4 Where wire rope is used in lieu of chain cable for anchoring, galvanised wire rope with an independent wire core in accordance with Annex 1 Chapter 10 is to be used. Wire rope terminal fittings are to comply with a recognised standard.

### 4.2 Manufacture and testing

4.2.1 Chain cables, steel wire ropes and shackles are to be manufactured and tested in accordance with the requirements of Annex 1.

### 4.3 Minimum Breaking Strength

4.3.1 The minimum breaking load of chain cables is to be calculated by the formulae given in Table 4.3.1.

The breaking loads of short-link chains and stud-link chains may be determined in accordance with Annex 1 Chapter 10.

4.3.2 Where the anchors have a mass greater than that required in 3.3.1 to 3.3.3, the breaking load of the anchor chain cable is to be determined as a function of that highest anchor mass.

4.3.3 The attachments between anchor and chain are to withstand a tensile load 20% higher than the tensile strength of the corresponding chain.

**Table 4.3.1: Breaking load R of chain cable**

| Anchor Mass [kg] | R [kN] |
|---|---|
| ≤ 500 | 0.35 P’ |
| > 500 and ≤ 2000 | $R = \left(0.35 - \frac{P' - 500}{15000}\right) P'$ |
| > 2000 | 0.25P’ |

Note: P’ is the theoretical mass of the anchor as established in accordance with 3.3 and 3.4

Where the actual anchor mass is greater than required, P ’ is to be taken as the actual anchor mass

Where the actual anchor is an anchor of the High Holding Power type, the equivalent mass of a normal anchor is to be used for *P*’

**Table 4.4.1 Minimum length of chain cable per anchor**

| *L*oa [m] | Minimum length of chain cable [m] | |
|---|---|---|
| | Zones 2 & 3 | Zone 1 |
| < 30 | 40 | *L*oa + 10 with a minimum of 40 [m] |

| | | |
|---|---|---|
| ≥ 30 and ≤ 50 | Loa + 10 | and need not be greater than 100 [m]. |
| > 50 | 60 | |

**4.4 Length of Chain Cables**

4.4.1 Bow anchor chain cables

Refer to Table 4.4.1 for the minimum length of bow anchor chain cables.

4.4.2 Stern anchor chain cables

The length of stern anchor chain cables is not to be less than 40 [m]. However, where vessels need to stop facing downstream they are to be equipped with a stern anchor chain of not less than 60 [m] in length.

**Section 5**

**Towlines and Mooring Lines**

**5.1 General**

5.1.1 Towlines and mooring lines may be of steel wire, natural fibre or synthetic fibre and are to be made by an approved manufacturer. During loading and unloading of tank vessels carrying inflammable liquids, steel wire ropes only are to be used for mooring purposes.

5.1.2 Vessels are to be equipped with three mooring lines. The length and breaking strength of mooring lines are to be as required by Table 5.1.2 and Table 5.1.3 respectively. Also see Sec.1.1.2.

Ropes and lines should preferably be of the following type:

— 6 × 24 wires + 7 fibre cores for towing ropes and mooring lines.

5.1.3 The diameter of a fibre rope is not to be less than 20 [mm]

**Table 5.1.2 : Mooring Lines**

| Mooring line | Minimum length [m] |
|---|---|
| 1st line | $l' = \min(l_1, l_2)$<br>$l_1 = L_{oa} + 20$<br>$l_2 = l_{max}$ [1] |
| 2nd line | $l'' = 2/3 * l'$ |
| 3rd line[2] | $l'' = 1/3 * l'$ |

1. $l_{max} = 100$ [m]
2. This line is not required on vessels with $L_{oa} < 20$ [m].

**Table 5.1.3 : Minimum breaking strength of mooring lines, Rs**

| Loa *B * T | Rs [kN] |
|---|---|
| ≤ 1000 [m$^3$] | $Rs = 60 + \frac{Loa * B * T}{10}$ |
| > 1000 [m$^3$] | $Rs = 150 + \frac{Loa * B * T}{100}$ |

5.1.4 Pushed barges may be equipped with atleast least four wire ropes having a theoretical breaking strength of 440 [kN] instead of the towing ropes.

**5.2 Manufacture and testing**

5.2.1 Steel wire ropes are to be manufactured and tested in accordance with the requirements of Annex 1 Ch.10.

**5.3 Mooring arrangement**

5.3.1 Means are to be provided to enable mooring lines to be efficiently secured on board ship by an adequate number of suitably placed bollards on either side of the ship.

5.3.2 Every vessel is to be equipped with one double bollard each on the fore and after body on port and starboard side. In between, depending on the vessel's size, one to three single bollards are to be arranged on either side of the vessel.

5.3.3 Mooring winches should be fitted with drum brakes of sufficient strength to prevent unreeling of the mooring lines.

5.3.4 Adequate stiffening is to be provided in way of Bollards, Mooring winches etc.

**5.4 Towing lines**

5.4.1 Tugs are to be equipped with a number of lines that are suitable for their operation. However, the main cable is to be at least 100 [m] long and have a breaking strength, in [kN], not less than one third of the total power, in [kW], of the main engine(s).

5.4.2 Self-propelled vessels and pushers that are also intended to tow are to be equipped with an at least 100 [m] long towing line whose breaking strength in [kN], is not less than one quarter of the total power, in [kW], of the main engine(s).

## Section 6

## Windlass

### 6.1 General

6.1.1 The requirements of 6.1.2 to 6.1.5 apply equally to bow and stern anchor winches.

6.1.2 On ships equipped with anchors having a mass of over 50 [kg], windlass(es) of sufficient power and suitable for the type and size of chain cable are to be fitted. Arrangements for anchor davits will be specially considered.

6.1.3 The windlasses may be hand or power operated. Hand operated windlasses are acceptable only if the effort required at the handle does not exceed 15 [kgf] for raising one anchor at a speed of not less than 2 [m/min] and making about 30 turns of the handle per minute.

6.1.4 A power operated windlass is to be capable of exerting, for a period not less than 30 minutes, a continuous duty pull of 28 $d_c^2$ [N] and to raise one anchor with chain cable at a mean speed of not less than 9 [m/min], $d_c$ [mm] being the diameter required for Grade CC1 chain cable.

6.1.5 Winches suitable for operation by hand as well as by external power are to be so constructed that the power drive cannot activate the hand drive.

### 6.2 Testing

6.2.1 After installation on board, anchoring tests are to be carried out to demonstrate satisfactory working.

# Chapter 14

# Welding

***Contents***

***Section***



## Section 1

## General

### 1.1 Scope

1.1.1 Welding in steel hull construction of all types of ships is to comply with the requirements of this Chapter.

Welding in aluminium structures will be specially considered.

### 1.2 Documentation

1.2.1 Connection details of the welded structural members, including type and size of welds are to be clearly indicated on the plans submitted for approval. An explanation of all symbols or abbreviations used in detailing the weld connections should be included on the plans.

Details of proposed welding procedure is to be submitted indicating preheating temperature and any postwelding heat treatment, if employed. Extent to which automatic welding, including deep penetration welding, is to be employed should also be indicated.

## Section 2

## Welding

### 2.1 Welders and supervision

2.1.1 Welders are to be proficient in the type of work on which they are to be engaged. The records of their tests and qualifications are to be kept by the builders and made available to the Surveyors. A sufficient number of skilled supervisors are to be employed to ensure effective control at all stages of assembly and welding operations.

### 2.2 Welding electrodes

2.2.1 Electrodes and welding consumables approved by Designated Authority in accordance with the requirements of Annex 1, Ch.11 and suitable for the type of joint and grade of steel, are to be used.

2.2.2 For the connection of two different grades of steel of the same tensile strength properties, electrodes suitable for the lower grade will be generally acceptable except at structural discontinuities or other points of stress concentration.

2.2.3 For the connection of steel of different tensile strengths, the electrodes are to be suitable for the tensile strength of the component, on the basis of which the weld fillet size has been determined in Sec.3.

**2.3 Preparation for welding**

2.3.1 The parts to be welded are to be fitted in accordance with the approved joint detail. The edge preparation is to be accurate and uniform. Means are to be provided for maintaining the parts to be welded, in correct position during the welding operations. Excessive force is not to be employed in aligning the parts before welding and the means employed in maintaining the alignment are to be so arranged as to allow for expansion and contraction during the welding operation. All methods employed in correcting improper alignment are to be to the satisfaction of the Surveyor.

2.3.2 All surfaces to be welded are to be clean, dry and free from rust, scale and grease. The surface and boundaries of each run of deposit are to be thoroughly cleaned and freed from slag before the next run is applied. Before a manual sealing run is applied to the back of a weld, the original root material is to be gouged out to sound metal.

2.3.3 Tack welding is to be kept to a minimum, and where used, should be equal in quality to that of the finished welds. Any defective tack weld is to be cut out before completing the finished welds. Care is to be taken in removing the tack welds to ensure that the structure is not damaged in doing so.

**2.4 Welding procedure**

2.4.1 Only approved welding procedures are to be used, See 2.5.

2.4.2 Structural arrangements are to be such as to allow adequate access for satisfactory completion of all welding operations. Welded joints are to be so arranged so as to facilitate downhand welding wherever possible.

2.4.3 The sequence of welding is to be so planned that any restraint during welding operations is reduced to a minimum. The ends of the frames and stiffeners should be left unattached to the plating at the subassembly stage until connecting welds are made, in the intersecting systems of plating, framing and stiffeners, at the erection stage.

Where a butt meets a seam, the welding of the seam should be interrupted well clear of the junction and not be continued until the butt is completed. Welding of the butt should continue past the open seam and the weld be chipped out for the seam to be welded straight through.

2.4.4 Adequate precautions are to be taken to ensure that the welding site is protected from the deleterious effects of high moisture, severe wind and extreme cold.

**2.5 Approval of procedures**

2.5.1 Unless previously approved, welding procedures are to be established by the yard and forwarded to Designated Authority for approval. The welding procedure specifications are to include detailed description of the base material, primer, plate thickness range, joint/groove design, welding consumable, welding position, welding techniques, welding parameters, preheating/ interpass temperature and post heat treatment if any.

The welding for procedure qualification and subsequent testing, are to be witnessed by the Surveyor of the Designated Authority.

**2.6 Inspection of welds**

2.6.1 Effective arrangements are to be provided for the inspection of finished welds to ensure that all welding has been satisfactorily completed.

2.6.2 All finished welds are to be visually inspected and are to be sound, uniform and substantially free from slag inclusions, porosity, undercutting or other defects. Welds and adjacent base metal are to be free from injurious arc strikes.

2.6.3 For the examination of important structural welds, visual inspection is to be supplemented by radiography or other acceptable non- destructive crack or flaw detection methods. The extent of such examination is to be to the Surveyors' satisfaction, but particular attention is to be given to the following locations:

a) Junction and crossings of seams and butts in strength deck, sheer strake, side and bottom shell within 0.4L amidships.

b) Butts of keel plating and rounded sheerstrake within 0.4L amidships.

c) Insert plates in way of hatch openings on the strength deck.

d) Butts of longitudinal framing and longitudinal bulkhead stiffeners within 0.4L amidships.

2.6.4 Defective sections of welds as found by visual or non- destructive examination or leakages under hydrostatic tests, are to be gouged out as necessary and carefully rewelded.

## Section 3

## Welded Connections

**3.1 Butt welds**

3.1.1 Plates of equal thickness may be manually butt welded as per Fig.3.1.1. For automatic welding procedures and special welding techniques, the welding procedure will be specially considered.

3.1.2 For joints of plates with difference in thickness of more than 4 [mm], the thicker plate is to be tapered. The taper is not to exceed 1:3. Edge preparation after the tapering is to be as indicated in Sec.3.1.1.

3.1.3 All manual butt welds are normally to be welded from both sides. Where a back ceiling run is

not practicable or in certain cases when the stress level in the members is very low, welding on one side may be permitted provided the welding process is found satisfactory.

3.1.4 Where stiffening members, attached by continuous fillet welds, cross the finished butt or seam welds, these welds are to be made flush in way of the faying surface. Similarly for butt welds in webs of stiffening members, the butt weld is to be first completed and made flush with the stiffening member before the stiffener is connected to the plating by fillet weld. The ends of the flush portion are to run out smoothly without notches or any sudden change of section. Where such conditions can not be complied with, a scallop is to be arranged in the web of the stiffening member. Scallops are to be of such size and in such a position, that a satisfactory weld can be made.

**3.2 'T' connections**

3.2.1 The throat thickness (See Fig.3.2.1) of the fillet welds is given by:

throat thickness = $t_p$ . weld factor . d/s

where,

$t_p$ = thickness [mm], of the thinner of the two parts being connected.

d = distance [mm], between the successive weld fillets.

s = length [mm], of the correctly proportioned weld fillets, clear of end craterss is not to be less than 75 [mm].

The weld factors for various connections are generally to be as given in Table - 3.2.1.

Where an approved automatic deep penetration procedure is used, the weld factors may be reduced by 15 per cent

3.2.2 The throat thickness is not to be less than 3.0 [mm] and generally not to be greater than 0.44 $t_p$ for double continuous welds and the greater of 0.44 $t_p$ or 4.5 [mm] for intermittent welds.

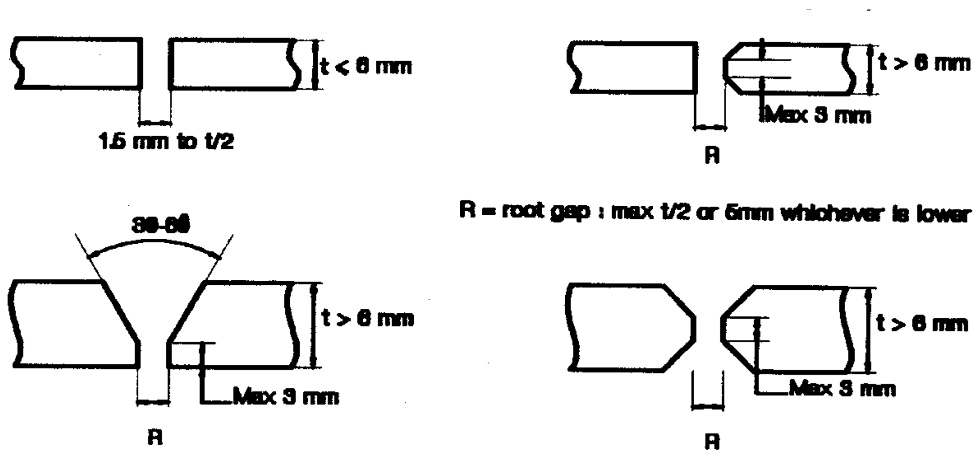



**Fig.3.1.1 : Manually welded butt joints**

| **Table 3.2.1 : Weld factors for fillet welds** | | | | | |
|---|---|---|---|---|---|
| | **Structural items** | **Weld Factors** | **d.c.** | **Int.weld** | **Remarks** |
| **Single Bottom** | | | | | |
| Centre girder | to keel plate or bar keel | 0.3 | * | | |
| | to face plate | 0.15 | | * | |
| Side girder | to bottom shell | 0.15 | | * | |
| | to face plate | 0.13 | | * | |
| | to floors | 0.20 | | * | |
| Floors | to keel plate | 0.15 | * | | |
| | to shell plating | 0.15 | | * | |

| | | | | | |
|---|---|---|---|---|---|
| | to centre girder | 0.35 | * | | |
| | to longitudinal bulkheads | 0.35 | * | | |
| | to face plate | 0.15 | | * | |
| | sterntube covering | 0.15 | * | | |
| Bottom longitudinal | to shell plating | 0.13 | | * | |
| **Double Bottom, See Note 1** | | | | | |
| Centre girder or duct keel | to keel plate | 0.3 | * | | |
| | to inner bottom | 0.25 | | * | |
| Side girder | to bottom shell | 0.15 | | * | |
| | to inner bottom | 0.15 | | * | |
| | to floors | 0.15 | | * | |
| Floors | to shell plating | 0.15 | | * | |
| | to inner bottom/margin plate | 0.15 | | * | |
| | to centre girder/keel plate | 0.20 | | * | |
| Margin plate | to shell plating | 0.4 | * | | |
| | to inner bottom | 0.4 | * | | |
| Inner bottom | to side shell | 0.4 | * | | |
| Tank side brackets | to shell plating | 0.3 | | * | |
| | to margin plate | 0.3, | | * | |
| Bracket floor | to inner bottom/bottom shell | 0.15 | | * | |
| | to centre girder | 0.25 | | * | |
| | to side shell/margin plate | 0.25 | | * | |
| Bottom frames | to shell plating | 0.13 | | * | |
| Reverse frames | to inner bottom | 0.13 | | * | |
| Longitudinals | to shell plating | 0.13 | | * | |
| | to inner bottom | 0.13 | | * | |
| Tank boundaries and bilge wells | | 0.40 | * | | |
| Stiffeners | to floors and girders | 0.13 | | * | |

| | **Structural items** | **Weld Factors** | **d.c.** | **Int.weld** | **Remarks** |
|---|---|---|---|---|---|
| **Structure in Machinery Space** | | | | | |
| Floors and girders | to shell & inner bottom | 0.3 | * | | |
| | to face plate | 0.2 | | * | |

| | | | | | |
|---|---|---|---|---|---|
| Transverse & longitudinal frames | to shell plating | 0.15 | | * | |
| Floors | to centre girder in way of engine, thrust blocks & boiler seatings | | | | |
| | – in single bottom | 0.50 | * | | |
| | – in double bottom | 0.30 | * | | |
| Main engine foundation girders | to top plate | 0.5 | * | | See Note 2 |
| | to hull structure | 0.4 | * | | |
| Floors | to engine girder | 0.4 | * | | |
| Brackets etc. | to engine girders | 0.3 | * | | |
| **Side Structure** | | | | | |
| Transverse frames | to side shell | | | | |
| | – in tanks | 0.13 | | * | |
| | – elsewhere | 0.11 | | * | |
| Side longitudinals | to shell plating | 0.13 | | * | |
| Web frames & side stringers | to shell plating | | | | |
| | – within 0.2 x span from ends | 0.35 | * | | |
| | – elsewhere | 0.20 | | * | |
| | to face plate and tripping bracket | 0.15 | | * | |
| Web frames | to side stringers | 0.3 | * | | |
| Bilge keel | to ground bars | 0.2 | * | | |
| Bilge keel ground bar | to side shell | 0.35 | * | | Single cont. |
| **Deck Structure** | | | | | |
| Strength deck | to shell | F.P. | | | See Note 3 |
| Other decks | to shell and bulkheads | 0.3 | * | | Generally |
| Deck beams | to deck plating | | | | |
| | – in tanks | 0.13 | | * | |
| | – elsewhere | 0.11 | | * | |
| Deck longitudinals | to decks | 0.13 | | * | |
| Deck girders | to deck plating | | | | |
| | – within 0.2 x span from ends | 0.35 | * | | |
| | – elsewhere | 0.20 | | * | |

| | | | | | |
|---|---|---|---|---|---|
| | to face plating and tripping brackets | 0.15 | | * | |
| Cantilever webs | to shell, decks, face plates and longitudinal girders at ends | 0.35 | * | | |
| Pillars | to deck, inner bottom and pillar brackets | 0.40 | * | | |

| | Structural items | Weld Factors | d.c. | Int.weld | Remarks |
|---|---|---|---|---|---|
| **Construction in 0.25L from F.P.** | | | | | |
| Floors & girders | to shell | 0.25 | * | | |
| | to inner bottom | 0.25 | | * | |
| Bottom longitudinals | to shell | 0.15 | | * | |
| Shell | to transverse & longitudinal side framing | 0.15 | | * | |
| Panting stringers | to shell & frames | 0.30 | * | | |
| All internal structure | in fore peak (unless a higher factor is specified) | 0.13 | | * | |
| **Aft Peak Construction** | | | | | |
| All internal structure | on bottom, side shell & aft peak bulkhead | 0.3 | * | | See 3.2.5 |
| **Bulkheads and Partitions** | | | | | |
| Boundaries of | watertight, oiltight & wash bulkheads and shaft tunnels | 0.4 | * | | To be specially considered for chemical cargo tanks |
| Stiffeners | on tank & wash bulkheads | 0.13 | | * | |
| | on pillar bulkheads | 0.13 | | * | |
| | on ordinary bulkheads | 0.11 | | * | |
| Vertical & horizontal girders in tanks & wash bulkheads | to bulkhead plating | | | | |
| | – within 0.2 x span from ends | 0.40 | * | | |
| | – elsewhere | 0.40 | | * | |
| | – to faceplate | 0.30 | | * | |
| | – to tripping brackets | 0.30 | | * | |
| Vertical & horizontal girders elsewhere | to bulkhead plating | 0.15 | | | |
| | – within 0.2 x span from ends | 0.35 | * | | |

| | | | | | |
|---|---|---|---|---|---|
| | – elsewhere | 0.20 | | * | |
| | to faceplate & tripping brackets | 0.15 | | * | |
| **Primary Structures in Cargo Tanks** | | | | | |
| Webs | to shell, deck & bulkheads | | | | |
| | – within 0.2 x span from ends | 0.4 | * | | |
| | – elsewhere | 0.3 | * | * | |
| Webs | to face plates | 0.3 | * | | |
| Webs | to webs of other primary members | 0.3 | * | | |
| Boundaries | of tripping brackets | 0.15 | | * | |
| **Superstructures & deckhouses** | | | | | |
| External bulkheads | to deck | | | | |
| | – on 1st and 2nd tiers | 0.40 | * | | |
| | – elsewhere | 0.25 | * | | |
| Internal bulkheads | boundaries | 0.13 | | * | |
| Stiffeners | to external bulkheads | 0.10 | | * | |

| | **Structural items** | **Weld Factors** | **d.c.** | **Int.weld** | **Remarks** |
|---|---|---|---|---|---|
| **Hatchways and closing appliances** | | | | | |
| Hatch coaming | to deck at corners | 0.5 | * | | |
| | to deck elsewhere | 0.4 | * | | |
| | to face plate | 0.4 | * | | |
| | to hatch cover rest bar | 0.16 | * | | |
| Hatch cover | to stiffeners | 0.12 | | * | |
| **Rudders & Nozzles** | | | | | |
| Rudders | | | | | See Note 4 |
| Main piece members | to coupling flange | F.P. | * | | |
| | to each other | 0.44 | * | | |
| Rudder plating | to rudder webs, elsewhere | 0.20 | * | | |
| Nozzles | generally as for rudders | | | | |
| **Miscellaneous fittings & equipment** | | | | | |
| Framing ring for manhole type covers | to deck & bulkhead | 0.4 | * | | |
| Framing around ports and W.T./oiltight doors | to plating | 0.4 | * | | |
| Sea-chest boundary | exposed to sea | 0.5 | * | | |

| | | | | | |
|---|---|---|---|---|---|
| welds | | | | | |
| | elsewhere | 0.4 | * | | |
| Ventilators, air pipes etc. | to deck | 0.4 | * | | |
| Bulwark stays | to deck | 0.4 | * | | |
| | to bulwark plating | 0.2 | | * | |
| Fabricated anchors | | F.P. | | | |
| Masts, derrick posts, crane pedestals, deck machinery & mooring equipment seating - to deck etc. | | To be considered in each individual case | | | |

d.c double continuous

F.P. Full penetration weld

Note 1 For tank boundaries see 3.2.5.

Note 2 Preferably to be deep penetration or full penetration weld depending on the thickness of the engine girders.

Note 3 Generally full penetration, but alternative proposals may be considered.

Note 4 See Chapter 12, Section 4.1.

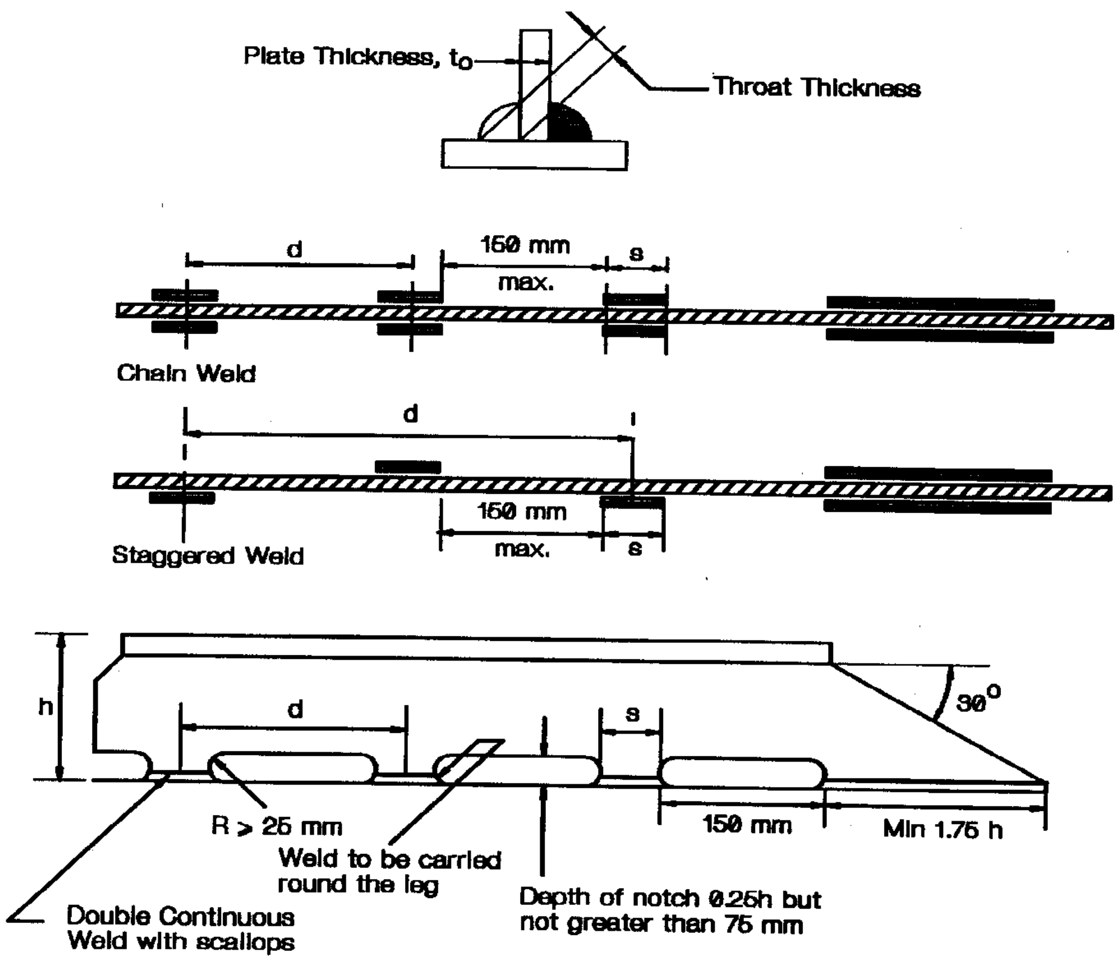



Fig.3.2.1 : Fillet welds

3.2.3 The leg length is not to be less than √2 times the specified throat thickness.

3.2.4 Where the connection is highly stressed, deep penetration or full penetration welding may be required. Where full penetration welding s required, the abutting plate may require to be beveled.

3.2.5 Continuous welding is to be adopted in the following locations and in any other region of high dynamic loading:-

a) Boundaries of weathertight decks and erections, including hatch coamings, companionways and other openings.

b) Boundaries of tanks and watertight compartments.

c) All structures in the afterpeak and the afterpeak bulkhead stiffeners.

d) All framing within holds of bulk carriers intended for carriage of coal.

e) All welding inside tanks intended for chemicals or edible liquid cargoes.

f) All lap welds in tanks.

g) Primary and secondary members to plating in way of end connections and end brackets to plating in the case of lap connection.

h) Other connections as given in Table - 3.2.1.

3.2.6 Where intermittent welding is used, the welding is to be made continuous around the ends of brackets, lugs, scallops and at other orthogonal connections with other members. In tanks for water ballast, cargo oil or fresh water, only scalloped welding is to be used.

3.2.7 Where structural members pass through the boundary of a tank, and leakage into the adjacent space could be hazardous or undesirable, full penetration welding is to be adopted for the members for at least 150 [mm] on each side of the boundary. Alternatively, a small scallop of suitable shape may be cut in the member close to the boundary outside the compartment, and carefully welded all round.

**3.3 Lap connections**

3.3.1 Overlaps are not to be used to connect plates which may be subjected to high tensile or compressive loading. However, where they are adopted, the width of overlap is to be adequate to ensure a good weld, the surfaces are to be in close contact and the joints should be closed all round by continuous fillet weld.

**3.4 Slot weld**

3.4.1 For the connection of plating to internal webs, where access for welding is not practicable, the closing plating is to be attached by continuous full penetration or slot welds to flat bars fitted to the webs. Slots are to be well rounded at ends, to have a minimum length of 75 [mm] and in general, a minimum width of twice the plating thickness. The distance between the slots is not to exceed 150 [mm]. Complete filling of the slots is normally not permitted.

**3.5 End connection**

3.5.1 In way of the end connections of girders double continuous welding is to be used all around. The weld area is not to be less than the cross-sectional area of the member, and the throat thickness not less than that given by Table 3.2.1 for girder ends.

3.5.2 Where stiffeners have bracketed end connections, bracket arms are to be welded all around and the throat thickness is not to be less than 0.35 times the thickness of bracket.

3.5.3 Where stiffeners are continuous at girder, they are to be connected to the webs, either directly and/or by means of lugs. The weld area is to be such that the shear stress does not exceed 80/k [N/mm$^2$]. Where the shear forces are high, a double sided connection to the web and/or a web stiffener welded on top of the continuous stiffener may be required.

## Chapter 15

## Hull Inspection, Workmanship and Testing

*Contents*



## Section 1

## Hull Inspection

### 1.1 Approval of works

1.1.1 The builders are to demonstrate their capability to carry out the fabrication to acceptable quality standards before the commencement of the fabrication. Similar approval procedure shall apply to subcontractor's works also. Previous experience in the building and repair of relevant structures and equipment can be considered favourably in this regard.

### 1.2 Inspection facilities

1.2.1 Adequate facilities are to be provided to enable the Surveyor to carry out a satisfactory inspection of all components during each stage of prefabrication and construction.

## Section 2

## Workmanship

### 2.1 General

2.1.1 All workmanship is to be of good quality and in accordance with good shipbuilding practice. Any defect is to be rectified to the satisfaction of the Surveyor before being covered with paint, cement or other composition.

2.1.2 The assembly sequence and welding sequence are to be agreed prior to construction and are to be to the satisfaction of the Surveyor.

### 2.2 Plate edges and cut-outs

2.2.1 Openings, holes and other cut-outs in the main structural components are to be rounded off by adequately large radii. The free edges of cut-outs, hatch corners etc. are to be properly prepared and are to be free from notches. All edges should be faired.

### 2.3 Cold forming

2.3.1 Flanging and bending of plates while cold forming are not to have an average bending radius less than three times the plating thickness. The minimum radius is not to be less than twice the plating thickness.

2.3.2 During joggling of plates and profiles, the depth of joggle is not to be less than four times and the bending radius not less than twice the web thickness.

### 2.4 Hammering, bending and straightening

2.4.1 Steel being worked on when hot, is not to be overheated, and it is to be hammered and bent in the appropriate heat condition. Steel which is burnt, is not to be used.

2.4.2 Flame heating may be employed to straighten buckled plating when the buckling is not severe.

## Section 3

## Testing

### 3.1 Definitions

3.1.1 Shop primer is a thin coating applied after surface preparation and prior to fabrication as a protection against corrosion during fabrication.

Protective coating is a final coating protecting the structure from corrosion.

3.1.2 Structural testing is a hydrostatic test carried out to demonstrate the tightness of the tanks and the structural adequacy of the design. Where practical limitations prevail and hydrostatic testing is not feasible (for example when it is difficult, in practice, to apply the required head at the top of the tank), hydropneumatic testing may be carried out instead. When a hydropneumatic testing is performed, the conditions should simulate, as far as practicable, the actual loading of the tank.

3.1.3 Hydropneumatic testing is a combination of hydrostatic and air testing, consisting of filling the tank with water up to its top and applying an additional air pressure. The value of the additional air pressure is to be at least as given in Sec.3.4.

3.1.4 Leak testing is an air or other medium test carried out to demonstrate the tightness of the structure.

3.1.5 Hose testing is carried out to demonstrate the tightness of structural items not subjected to hydrostatic or leak testing and to other components which contribute to the watertight or weathertight integrity of the hull.

**3.2 Application**

The requirements of this Section apply to:

- tanks, including independent tanks
- watertight or weathertight structures.

The purpose of these tests is to check the tightness and/or the strength of structural elements.

Tests are to be carried out in the presence of the Surveyor at a stage sufficiently close to completion so that any subsequent work would not impair the strength and tightness of the structure.

For the general testing requirements, See Sec.3.8 and Sec.3.9.

**3.3 Structural testing**

3.3.1 Structural testing as required in Table 3.3.1 may be carried out before or after launching.

Shop primer may be applied before carrying out the structural testing.

3.3.2 Structural testing may be carried out after the protective coating has been applied, provided that one of the following two conditions is satisfied:

a) all the welds are completed and carefully inspected visually to the satisfaction of the Surveyor, prior to the application of the protective coating,

b) leak testing is carried out prior to the application of the protective coating.

However, when leak testing is not carried out, protective coating in way of the following welds should be applied only after the structural testing has been satisfactorily completed:

- all erection welds, both manual and automatic
- all manual fillet weld connections on tank boundaries and manual penetration welds.

**3.4 Leak testing**

3.4.1 Where leak testing is carried out in accordance with Table 3.3.1, an air pressure of 7 [KN/m$^2$] is to be applied during the test.

Prior to inspection, it is recommended that the air pressure in the tank is raised to 10 [KN/m$^2$] and kept at this level for about 1 hour to reach a stabilized state, with a minimum number of personnel in the vicinity of the tank, and then lowered to the test pressure.

3.4.2 Welds are to be coated with an efficient indicating liquid.

3.4.3 A U-tube filled with water up to a height corresponding to the test pressure is to be fitted to avoid overpressure of the compartment tested and to verify the test pressure. The U-tube should have a cross section larger than that of the pipe supplying air.

In addition, the test pressure is also to be verified by means of one master pressure gauge. Alternative means which are considered to be equally reliable, may be accepted.

3.4.4 Where leak testing is carried out it should be prior to the application of a protective coating, on all fillet weld connections on tank boundaries, penetrations and erection welds on tank boundaries excepting welds made by automatic processes. Selected locations of automatic erection welds and pre-erection manual or automatic welds may require to be similarly tested at the discretion of the Surveyor, taking account of the quality control procedures operating in the shipyard. For other welds, leak testing may be carried out after the protective coating has been applied, provided that these welds were carefully inspected visually to the satisfaction of the Surveyor.

Any other recognized method may be accepted to the satisfaction of the Surveyor.

**3.5 Hose testing**

When hose testing is required to verify the tightness of the structures, as defined in Table 3.3.1, a minimum pressure in the hose of at least 200 [KN/m$^2$] is to be applied at a maximum distance of 1.5 [m]. The nozzle diameter is not to be less than 12 [mm].

**3.6 Hydropneumatic testing**

When hydropneumatic testing is performed, the same safety precautions as for leak testing (See Sec.3.4) are to be adopted.

**3.7 Other testing methods**

Other testing methods may be accepted, at the discretion of the Designated Authority, based upon equivalency considerations.

**3.8 General testing requirements**

General requirements for testing are given in Table 3.3.1.

**3.9 Additional requirements for special type vessels/tanks**

In addition to the requirements of Table 3.3.1, particular requirements for testing of certain spaces within the cargo area of following types of vessels are given in Table 3.9.1.

- edible liquid carriers
- chemical carriers

These requirements intend generally to verify the adequacy of the structural design of the tank, based on the loading conditions on which the scantlings of the tank structure were determined.

**Table 3.3.1 : General testing requirements**

| Item number | Structure to be tested | Type of testing | Structural test pressure | Remarks |
|---|---|---|---|---|
| 1 | Double bottom tanks | Structural testing[a] | The greater of the following:<br>– head of water up to the top of overflow<br>– head of water up to the uppermost continuous deck | Tank boundaries tested from at least one side |
| 2 | Double side tanks | Structural testing[a] | The greater of the following:<br>– head of water upto the top of overflow<br>– 1.0 [m] head of water above highest point of tank | Tank boundaries tested from at least one side |
| 3 | Tank bulkheads, deep tanks | Structural testing[a] | The greater of the following[b]:<br>– head of water up to the top of overflow<br>– 1.0 [m] head of water above highest point of tank<br>– setting pressure of the safety relief valves, where relevant | Tank boundaries tested from at least one side |
| | Fuel oil bunkers | Structural testing | | |
| 4 | Fore peak and after peak used as tank | Structural testing | The greater of the following:<br>– head of water up to the top of overflow<br>– 1.0 [m] head of water above highest point of tank | Test of the after peak carried out after the stern tube has been fitted |
| | Fore peak not used as tank | Structural testing | – head of water upto the uppermost continuous deck for cargo ships and bulkhead deck for passenger ships | |
| | After peak not used as tank | Leak testing | | |
| 5 | Watertight bulkheads | Hose testing[c] | | Thorough inspection of bulkhead to be carried out |
| 6 | Watertight doors below uppermost continuous deck or bulkhead deck | Structural testing[d] | – Water pressure head upto the uppermost continuous deck for cargo ships and bulkhead deck for passenger ships | |
| 7 | Double plate rudders | Leak testing | | |
| 8 | Shaft tunnel clear of deep tanks | Hose testing | | |
| 9 | Shell doors | Hose testing | | |
| 10 | Weathertight hatchcovers and closing appliances | Hose testing | | |

| | | | | |
|---|---|---|---|---|
| 11 | Chain locker (if aft of collision bulkhead), | Structural testing | Head of water up to the top | |
| 12 | Independent tanks | Structural testing | Head of water upto the top of overflow, but not less than 0.9 [m], | |
| 13 | Ballast ducts | Structural testing | Ballast pump maximum pressure | |

Notes:

[a] Leak or hydropneumatic testing may be accepted under the conditions specified in 3.4, provided that at least one tank for each type is structurally tested. This however does not apply to cargo space boundaries in tankers and tanks for segregated cargoes or pollutants. If the structural test reveals weakness or severe faults not detected by the leak test, all tanks are to be structurally tested.

[b] Where applicable, the highest point of tank is to be measured to the deck and excluding hatches.

[c] When hose test cannot be performed without damaging possible outfitting (machinery, cables, switchboards, insulation, etc.) already installed, it may be replaced, at the discretion of the Designated Authority by a careful visual inspection of all the crossings and welded joints; where necessary, dye penetrant test or ultrasonic leak test may be required.

[d] The test may be made before or after the door is fitted. In case test is done before, hose testing is to be carried out in place after the door is fitted.

**Table 3.9.1 : Additional testing requirements for spaces within the cargo area of certain types of ships**

| **Item No.** | **Types of ships** | **Structure to be tested** | **Testing requirements** | **Structural test pressure** | **Remarks** |
|---|---|---|---|---|---|
| 1 | Edible liquid carriers | Independent tanks | Structural testing | Head of water up to the top of overflow without being less than 0.9 [m] | |
| 2 | Chemical carriers | Integral or independent tanks | Structural testing of cargo tanks boundaries from at least one side | The greater of the following:<br>– 1.0 [m] head of water above highest point of tank<br>– setting pressure of the safety relief valves, where relevant | |

**Annex 3**

**Main and Auxiliary Machinery**

**Contents**



**Annex 3**

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## Chapter 1

## General Requirements for the Design and Construction of Machinery

***Contents***



## Section 1

## General

### 1.1 Scope

1.1.1 The requirements of this Chapter and those given in Ch.2 to 10 apply to the construction and installation of main propulsion and auxiliary machinery systems, together with their associated equipment, boilers, pressure vessels and pumping and piping arrangements.

### 1.2 Machinery to be constructed under survey

1.2.1 In ships intended to be built under Special Survey, all important units of equipment are to be surveyed at the manufacturer's works. The workmanship is to be to the Surveyor's satisfaction and the Surveyor is to be satisfied that the components are suitable for the intended purpose and duty. Examples of such units are :

- Main propulsion engines, including their associated gearing, flexible couplings, scavenge blowers and superchargers;
- Boilers supplying steam for propulsion or for services essential for the safety or the operation of the ship at sea, including superheaters, economisers, desuperheaters, steam receivers. All other boilers having working pressures exceeding 3.5 bar, and having heating surfaces greater than 4.65 [$m^2$];
- Auxiliary engines of 110 [kW] (150 shp) and over which are the source of power for services essential for safety or for the operation of the ship.
- Steering machinery;
- Athwartship thrust units, their prime movers and control mechanisms;
- All pumps necessary for the safety of vessel, e.g. bilge, ballast, fire pumps, etc.;
- Air compressors, air receivers and other pressure vessels necessary for the operation of main propulsion and essential machinery.
- Alarm and control equipment as detailed in Ch.7; and
- Electrical equipment and electrical propelling machinery as detailed in Ch.8.

### 1.3 Extent of survey

1.3.1 The Surveyors are to examine and test the materials and workmanship from the commencement of work until the final test of the machinery under full power working conditions. Any defects, etc., are to be indicated as early as possible.

### 1.5 Plans and particulars

1.5.1 Before the work is commenced, plans in triplicate of all machinery items, as detailed in the Ch.2 to 9 giving the requirements for individual systems, are to be submitted for approval. The particulars of the machinery, including power ratings and design calculations, where applicable, necessary to verify the design, are also to be submitted. Any subsequent modifications are subject to approval before being put in to operation.

1.5.2 The strength requirements for rotating parts of the machinery, as specified in Ch.4 to 8, are based upon strength consideration only and their application does not relieve the manufacturer from the responsibility for the presence of dangerous vibrations in the installation at speeds within the operating range.

### 1.6 Availability of machinery for operation

1.6.1 The design and arrangement is to be such that the machinery can be started and controlled on board ship without external aid, so that operating conditions can be maintained under all circumstances.

### 1.7 Ambient reference conditions

1.7.1 The rating of the main and auxiliary machinery is to be suitable for the temperature conditions associated with the geographical limits of the restricted service.

1.7.2 Machinery installations are to be designed such as to ensure proper operations under the conditions as under:

– Permanent list of 10°

– Permanent trim of 5°

**1.8 Power ratings**

1.8.1 In the following Chapters, where the dimensions of any particular component are determined from shaft power, P in [kW] (H, in shp), and revolutions per minute, R, the values to be used are to be derived from the following :

– For main propelling machinery, the maximum shaft power and corresponding revolutions per minute giving the maximum torque for which the machinery is to be classed; and

– For auxiliary machinery, the maximum continuous shaft power and corresponding revolutions per minute which will be used in service.

**1.9 Units**

1.9.1 Units and formulae included in the requirements are shown in SI units followed by metric units in brackets, where appropriate.

1.9.2 Where the metric version of shaft power, i.e. (shp), appears in the requirements, 1 shp is equivalent to 75 [kgf metre/sec] or 0.735 [kW].

1.9.3 Pressure gauges may be calibrated in bar,

where,

1 bar = 0.1 [N/mm$^2$] = 1.02 [kgf/cm$^2$]

**1.10 Power conditions for generator sets**

1.10.1 Auxiliary engines coupled to electrical generators are to be capable under service conditions of developing continuously the power to drive the generators at full rated output and, if developing for a short period (15 minutes) an overload power of not less than 10 per cent.

1.10.2 Engine builders are to satisfy the Surveyors by tests on individual engines that the above requirements, as applicable, can be complied with, due account being taken of the deference between the temperature under test conditions and those specified in 1.7.1. Alternatively, where it is not practicable to test the engine/generator set as a unit, type tests (e.g. against a brake) representing a particular size and range of engines may be accepted. With oil engines any fuel stop fitted is to be set to permit the short period overload power of not less than 10 per cent above full rated output being developed.

**1.11 Fuel**

1.11.1 The flash point (closed cup test) of oil fuel is to be not less than 55°C, unless specially approved. 1.11.2 Fuels with flash points lower than 55°C, but not less than 43°C, unless specially approved, may be used in ships intended for service restricted to certain geographical limits, where it can be ensured that the temperature of the machinery spaces will always be 10°C below the flash point of the fuel.

In such cases, safety precautions and the arrangements for storage and pumping will be specially considered.

**1.12 Astern power**

1.12.1 Sufficient astern power is to be provided to maintain control of the ship in all normal circumstances.

**Section 2**

**Machinery Room Arrangements**

**2.1 General**

2.1.1 The machinery is to be so designed, installed and protected that risks of fire, explosions, accidental pollution, leakages and accidents thereof, and accidents to personnel working in machinery spaces will be minimised.

2.1.2 The design and arrangement of machinery foundations, shaft connections, piping and ducting is to take into account the effects of thermal expansion, vibrations, mis-alignment and hull interaction to ensure operation within safe limits. Bolts and nuts exposed to dynamic forces and vibrations are to be properly secured.

**2.2 Accessibility**

2.2.1 Accessibility, for attendance and maintenance purposes, is to be provided for machinery plants.

**2.3 Fire protection**

2.3.1 All surfaces of machinery where the surface temperature may exceed 220°C and where impingement of flammable liquids may occur are to be effectively shielded to prevent ignition. Where insulation covering these surfaces is oil absorbing or may permit penetration of oil, the insulation is to be encased in steel or equivalent.

2.3.2 Flammable or oil absorbing materials are not to be used in floors, gratings, etc. in boiler and engine rooms, shaft tunnels or in compartments where settling tanks are installed.

**2.4 Ventilation**

2.4.1 All spaces, including engine and cargo pump spaces, where flammable or toxic gases or vapours may accumulate, are to be provided with adequate ventilation under all conditions.

**2.5 Communications**

2.5.1 At least one independent means of communication is to be provided between the bridge and engine room control station.

## Section 3

## Trials

### 3.1 General

3.1.1 Tests of components and trials of machinery, as detailed in the Chapters giving the requirements for individual systems are to be carried out to the satisfaction of the Surveyors.

### 3.2 Trials

3.2.1 For all types of installations, the trials are to be of sufficient duration, and carried out under normal maneuvering conditions, to prove the machinery under power. The trials are also to demonstrate that any vibration which may occur within the operating speed range is acceptable.

3.2.2 The trials are to include demonstrations of the following :

- The adequacy of the starting arrangements to provide the required number of starts of the main engines;
- The ability of the machinery to reverse the direction of thrust of the propeller in sufficient time, under normal maneuvering conditions, and so bring the ship to rest from maximum ahead rated speeds.

3.2.3 Where controllable pitch propellers are fitted, the free route astern trial is to be carried out with the propeller blades set in full pitch astern position. Where emergency manual pitch setting facilities are provided, their operation is to be demonstrated to the satisfaction of the Surveyors.

3.2.4 All trials are to be to Surveyor's satisfaction.

## Chapter 2

## Piping Design Requirements

***Contents***



## Section 1

## General

### 1.1 Scope

1.1.1 The requirements of this Chapter apply to the design and construction of piping systems, including pipe fittings forming parts of such systems but excluding steam piping systems and systems where the temperature exceeds 300°C.

1.1.2 Steam piping systems and systems having temperatures greater than 300°C will be specially considered.

### 1.2 Classes of pipes

1.2.1 For the purpose of testing, type of joints to be adopted, heat treatment and welding procedure, piping systems are divided into three classes, as given in Table 1.2.1.

.

1.2.3 In addition to the pressure piping systems in Table 1.2.1, Class III pipes may be used for open ended piping, e.g. overflows, vents, boiler waste steam pipes, open ended drains etc.

### 1.3 Design pressure

1.3.1 The design pressure, P, is the maximum permissible working pressure and is to be not less than the highest set pressure of the safety valve or relief valve.

1.3.2 The design pressure of feed piping and other piping on the discharge from pumps is to be taken as the pump pressure at full rated speed against a shut valve. Where a safety valve or other protective device is fitted to restrict the pressure to a lower value than the shut valve load, the design pressure is to be the highest set pressure of the protective device.

**Table 1.2.1 : Classes of piping systems**

| Piping system | Class I | Class II | Class III |
|---|---|---|---|
| Fuel oil | $P > 16$ or $T > 150$ | $P \leq 16$ and $T \leq 150$ | $P \leq 7$ and $T \leq 60$ |
| Other media | $P > 49$ or $T > 300$ | $P \leq 40$ and $T \leq 300$ | $P \leq 16$ and $T \leq 200$ |

### 1.4 Design temperature

1.4.1 The design temperature is to be taken as the maximum temperature of the internal fluid, but in no case is it to be less than 50°C.

### 1.5 Design symbols

1.5.1 The symbols used in this Chapter are defined as follows :

a = percentage negative manufacturing tolerance on thickness;

b = bending allowance [mm];

c = corrosion allowance [mm];

D = outside diameter of pipe [mm] (see 1.5.2);

d = inside diameter of pipe [mm] (see 1.5.3);

e = weld efficiency factor (see 1.5.4);

P = design pressure, in [N/mm$^2$];

Pt = hydraulic test pressure, in [N/mm$^2$];

R = radius of curvature of a pipe bend at the centreline of the pipe [mm];

T = design temperature, in C°;

t = the minimum thickness of a straight pipe [mm] including corrosion allowance and negative tolerance, where applicable;

$t_b$ = the minimum thickness of a straight pipe to be used for a pipe bend [mm] including bending

allowance, corrosion allowance and negative tolerance, where applicable;

$\sigma$ = maximum permissible design stress, in [N/mm$^2$].

1.5.2 The outside diameter, D, is subject to manufacturing tolerance, but these are not to be used in the evaluation of formulae.

1.5.3 The inside diameter, d, is not to be confused with nominal size, which is an accepted designation associated with outside diameters of standard rolling sizes.

1.5.4 The weld efficiency factor, e, is to be taken as1.0 for seamless and electric resistance and induction welded steel pipes. Where other methods of pipe manufacture are proposed, the value of e will be specially considered.

**1.6 Heat treatment**

1.6.1 Method of heat treatment and means of temperature control and recording are to be to the satisfaction of Surveyors.

## Section 2

## Carbon and Low Alloy Steel Pipes and Fittings

**2.1 Materials**

2.1.1 Materials for Class I and Class II piping systems, also for ship-side valves and fittings and valves on the collision bulkhead, are to be manufactured and tested in accordance with the appropriate requirements of Annex 1 *Ch.8.*

2.1.2 Materials for Class III piping systems may be manufactured and tested in accordance with the requirements of acceptable national /international specifications. Pipes having forge butt welded longitudinal seams are not to be used for oil fuel systems, for heating coils in oil tanks, or for pressures exceeding 0.4 [N/mm$^2$]. The manufacturer's test certificate will be acceptable and is to be provided for each consignment of material.

**2.2 Minimum thickness of steel pipes and bends**

2.2.1 The maximum permissible design stress, $\sigma$, is to be taken as the lowest of the following values :-

$$\sigma = \frac{Et}{1.6} \ or \ \sigma = \frac{R_{20}}{2.7} \text{ or } \sigma = \frac{S_R}{1.6}$$

where,

Et = specified minimum lower yield or 0.2 per cent proof stress at the design temperature,

$R_{20}$ = specified minimum tensile strength at ambient temperature,

$S_R$ = average stress to produce rupture in 100,000 hours at the design temperature.

**Table 2.2.1 : Carbon and carbon-manganese steel pies : Maximum permissible stress [N/mm$^2$]**

| **Design temp.°C** | **Specified minimum tensile strength [N/mm$^2$]** | | | | |
|---|---|---|---|---|---|
| | **320** | **360** | **410** | **460** | **490** |
| 50 | 107 | 120 | 136 | 151 | 160 |
| 100 | 105 | 117 | 131 | 146 | 156 |
| 150 | 99 | 110 | 124 | 139 | 148 |
| 200 | 92 | 103 | 117 | 132 | 141 |
| 250 | 78 | 91 | 106 | 122 | 131 |
| 300 | 62 | 76 | 93 | 111 | 121 |

2.2.2 The minimum thickness, t, of straight steel pipes is to be determined by the following formula :-

$$t = \left( \frac{PD}{2\sigma e + P} + c \right) \frac{100}{100 - a} \ \text{[mm]}$$

where,

P, D, e and a are defined in Sec.1, Cl.1.5.1

$\sigma$ is defined in 2.2.1 and also obtained from Tables 2.2.1.

c is obtained from Table 2.2.2.

**Table 2.2.2 : Values of c for steel pipes**

| **Piping service** | **C [mm] (See Note)** |
|---|---|
| Compressed air systems | 1.0 |
| Hydraulic/Lubricating oil systems | 0.3 |
| Fuel oil systems | 1.0 |
| Cargo oil systems | 2.0 |
| Refrigerating plants | 0.3 |
| Fresh water systems | 0.8 |

Note:

For pipes passing through tanks an additional corrosion allowance is to be considered according to the figures given in Table and depending upon the external medium in order to account for the external corrosion.

2.2.3 The minimum thickness, $t_b$, of a straight steel pipe to be used for a pipe bend is to be determined by the following formula, except where it can be demonstrated that the use of a thickness less than $t_b$ would not reduce the thickness below 't' at any point after bending :-

$$t_b = \left( \frac{PD}{2\sigma e + P} + b + c \right) \frac{100}{100 - a} \quad [mm]$$

where,

P, D, R, e, b and a are defined in Sec.1, Cl.1.5.1;

σ and c are defined in tables 2.2.1 and 2.2.2 respectively;

$$b = \frac{D}{2.5R} \left( \frac{PD}{2\sigma e + P} \right) [mm]$$

In general, R, is to be not less than 3D.

2.2.4 The minimum thickness calculated in accordance with 2.2.2 and 2.2.3 is not to be less than that given in Table 2.2.4. Where the pipes are efficiently protected against corrosion, the thickness may be reduced by not more than 1.0 [mm]. For threaded pipes, where permitted, the thickness is to be measured at the bottom of the threads.

**Table 2.2.4 : Minimum pipe thicknesses, t [mm] (see note)**

| External diameter D [mm] | Pipes in general | Venting overflow & sounding pipes for structural tanks |
|---|---|---|
| 10.2 - 12 | 1.6 | - |
| 13.5 - 19.3 | 1.8 | - |
| 20 | 2 | - |
| 21.3 - 25 | 2 | - |
| 26.9 - 33.7 | 2 | - |
| 38 - 44.5 | 2 | 4.5 |
| 48.3 | 2.3 | 4.5 |
| 51 - 63.5 | 2.3 | 4.5 |
| 70 | 2.6 | 4.5 |
| 76.1 - 82.5 | 2.6 | 4.5 |
| 88.9 - 108 | 2.9 | 4.5 |
| 114.3 - 127 | 3.2 | 4.5 |
| 133 - 139.7 | 3.6 | 4.5 |
| 152.4 - 168.3 | 4 | 4.5 |
| 177.8 | 4.5 | 5 |
| 193.7 | 4.5 | 5.4 |
| 219.1 | 4.5 | 5.9 |
| 244.5 - 273 | 5 | 6.3 |
| 298.5 - 368 | 5.6 | 6.3 |
| 406.4 - 457.2 | 6.3 | 6.3 |

**2.3 Flange connections**

2.3.1 Flanges with their pressure-temperature ratings in accordance with recognized national/international standards will normally be accepted.

2.3.2 Flanges may be cut from plates or may be forged or cast. The material is to be suitable for the design temperature. Flanges may be attached to the branches by screwing and expanding or by welding. Alternative methods of flange attachment may be accepted provided details are submitted for consideration.

2.3.3 Examples of accepted flanged connections and their uses are given in Fig. 2.3.1 and Table 2.3.1 respectively.

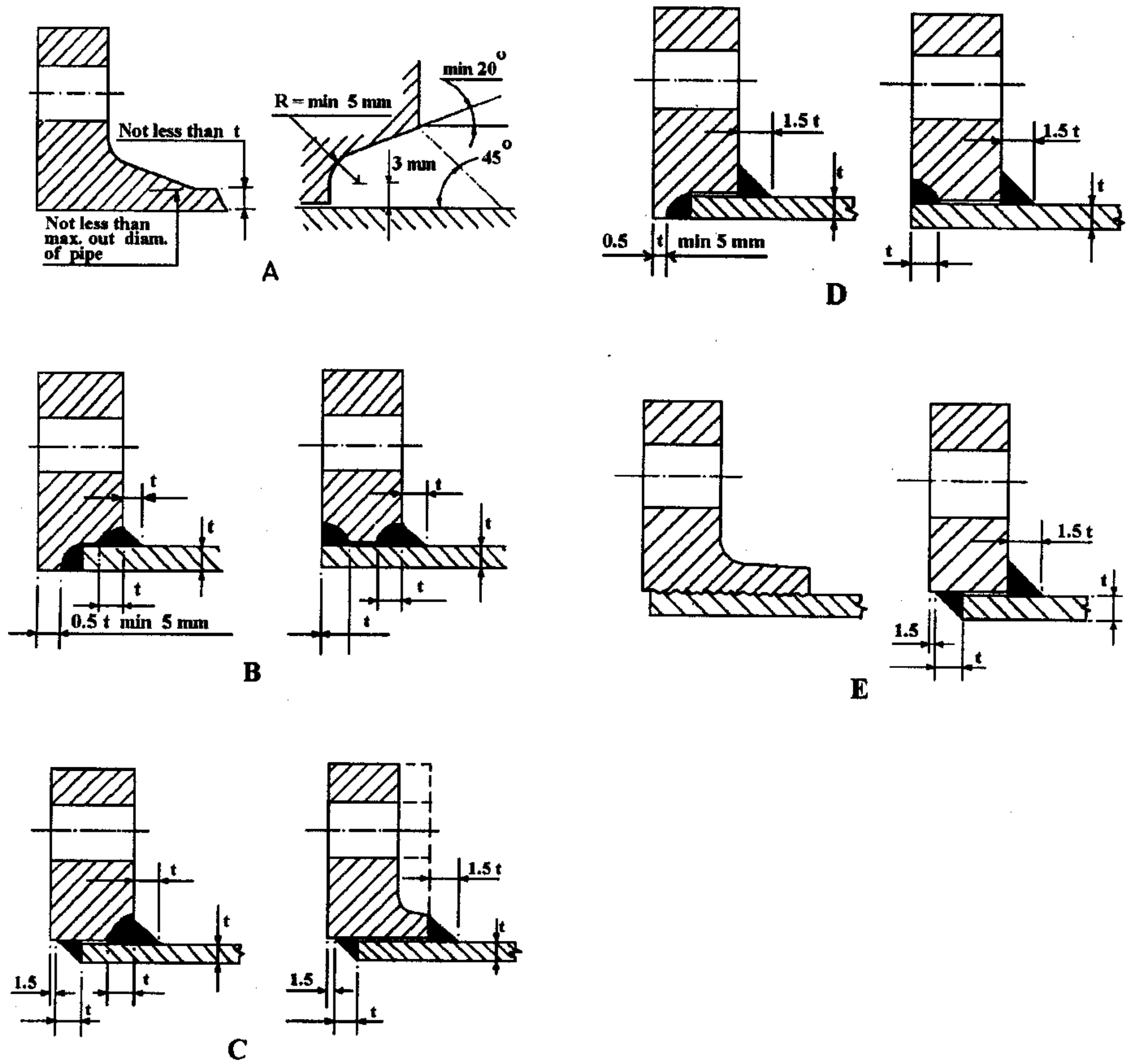


Fig. 2.3.1

**Table 2.3.1 : Type of flange connections**

| Class of piping | Lub. and fuel oil | Other media | |
|---|---|---|---|
| | Typical flange application | t°C | Typical flange application |
| II | A - B - C | > 250 ≤ 250 | A - B - C<br>A - B - C - D - E |
| III | A - B - C - E | | A - B - C -D - E |

2.3.4 Where flanges are secured by screwing, as indicated in Fig.2.3.1, the pipe and flange are to be screwed with a vanishing thread and the diameter of the screwed position of pipe over the thread is not to be appreciably less than the outside diameters of the unscrewed pipe. After the flange has been screwed hard home, the pipe is to be expanded into the flange. The vanishing thread on a pipe is to be not less than three pitches in length, and the diameter at the root of the thread is to increase uniformly from the standard root diameter to the diameter at the top of the thread. This may be produced by suitably grinding the dies, and the flange should be tapered out to the same formation.

**2.4 Threaded sleeve joints**

2.4.1 Threaded sleeve joints, in accordance with national or other established standards, may be used with carbon steel pipes within the limits given in Table 2.4.1 and for services other than pipe systems conveying combustible fluids.

**Table 2.4.1 : Limiting design conditions for threaded sleeve joints**

| Nominal bore [mm] | Maximum pressure [N/mm$^2$] | Maximum temperature °C |
|---|---|---|
| ≤ 25 | 1.2 | 260 |
| > 25 ≤ 40 | 1.0 | 260 |
| > 40 ≤ 80 | 0.85 | 260 |
| > 80 ≤ 100 | 0.7 | 260 |

**2.5 Non-destructive examination of welded pipes**

2.5.1 In addition to visual examination of pipe welds by the Surveyors, non-destructive examination of butt and fillet welds is to be carried out in accordance with 2.5.2 to 2.5.4 to the satisfaction of the Surveyors.

2.5.2 Selected butt welds of pipes of outside diameter of 101.6 [mm] and over in Class II piping systems are to be radiographed at Surveyor's discretion. Use of ultrasonic examination in lieu of radiography will be specially considered.

2.5.3 Selected fillet welds in pipes of 101.6 [mm] outside diameter and over in Class II piping systems are to be examined by magnetic particle or liquid penetrant flaw testing at Surveyor's discretion.

2.5.4 Defects in welds are to be rectified and re-examined by the appropriate test method, all to the satisfaction of the Surveyors.

**2.6 Post-weld heat treatment**

2.6.1 Carbon and carbon-manganese steel pipes and fabricated branch pieces, manufactured from material having a carbon content not exceeding 0.25 per cent and having a thickness exceeding 30 [mm], are to be given a stress relieving heat treatment on completion of welding. All pipes and branches having a carbon content in excess of 0.25 per cent are to be given a stress relieving heat treatment. Where oxy-acetylene welding has been employed, however, all the pipes and branch pieces are to be normalised on completion of welding.

## Section 3

## Copper and Copper Alloys Pipes and Fittings

**3.1 Materials**

3.1.1 Materials for Class II piping systems and shipside valves and fittings and valves on the collision bulkhead are to be manufactured and tested in accordance with the requirements of Annex 1 *Ch.8*.

3.1.2 Materials for Class III piping systems are to be manufactured and tested in accordance with the requirements of acceptable national/ international specifications. The manufacturer's test certificate will be acceptable and is to be provided for each consignment of material.

3.1.3 Pipes are to be seamless and branches are to be provided by cast or stamped fittings, pipe pressings or other approved fabrications.

3.1.4 Brazing and welding materials are to be suitable for the operating temperature and for the medium being carried. All brazing and welding are to be carried out to the satisfaction of the Surveyors.

3.1.5 In general, the maximum permissible service temperature of copper and copper alloy pipes, valves and fittings is not to exceed 200°C for copper and aluminium brass, and 300°C for copper nickel. Cast bronze valves and fittings complying with the requirements of Annex 1 *Ch.8* may be accepted up to 260°C.

**3.2 Minimum thickness of pipes**

3.2.1 The minimum thickness, t, of straight copper and copper alloy pipes is to be determined by the following formula :-

$$t = \left( \frac{PD}{2\sigma e + P} + c \right) \frac{100}{100 - a} \quad [mm]$$

where P, D and a are as defined in Sec.1, Cl.1.5.1;

σ = maximum permissible design stress, in [N/mm$^2$], from Table 3.2.1; Intermediate values of stresses may be obtained by linear interpolation;

c = corrosion allowance;

= 0.8 [mm] for copper, aluminium brass and copper-nickel alloys where the nickel content is less than 10 per cent;

= 0.5 [mm] for copper-nickel alloys where the nickel content is 10 per cent or greater;

= 0 where the media are non-corrosive relative to the pipe material.

**Table 3.2.1 : Copper and copper alloy pipes**

| Pipe material | Condition of supply | Specified min. tensile strength [N/mm$^2$] | Permissible stress [N/mm$^2$] | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Maximum design temperature °C | | | | | |
| | | | **50** | **75** | **100** | **125** | **150** | **175** |
| Copper | Annealed | 220 | 41.2 | 41.2 | 40.2 | 40.2 | 34.3 | 27.5 |
| Aluminium brass | Annealed | 320 | 78.5 | 78.5 | 78.5 | 78.5 | 78.5 | 51.0 |
| 90/10 copper nickel iron | Annealed | 270 | 68.6 | 68.6 | 67.7 | 65.7 | 63.7 | 61.8 |
| 70/30 copper nickel | Annealed | 360 | 81.4 | 79.4 | 77.5 | 75.5 | 73.5 | 71.6 |
| | | | **Maximum design temperature °C** | | | | | |
| | | | **200** | **225** | **250** | **275** | **300** | |
| Copper | Annealed | 220 | 18.6 | - | - | - | - | |
| Aluminium brass | Annealed | 320 | 24.5 | - | - | - | - | |
| 90/10 copper nickel iron | Annealed | 270 | 58.8 | 55.9 | 52.0 | 48.1 | 44.1 | |
| 70/30 copper nickel | Annealed | 360 | 69.6 | 67.7 | 65.7 | 63.7 | 61.8 | |

3.2.2 The minimum thickness, $t_b$, of a straight seamless copper or copper alloy pipe to be used for a pipe bend is to be determined by the formula below, except where it can be demonstrated that the use of a thickness less than $t_b$ would not reduce the thickness below `t` at any point after bending :

$$t_b = \left( \frac{PD}{2\sigma e + P} + b + c \right) \frac{100}{100 - a} \quad [\text{mm}]$$

where P, D, b and c are defined in Sec.1, Cl.1.5.1, and e and c are defined in 3.2.1

$$b = \frac{D}{2.5R} \left( \frac{PD}{2\sigma e + P} \right) \quad [\text{mm}]$$

In general, R is to be not less than 3D.

**Table 3.2.2 : Limiting design conditions for threaded sleeve joints**

| Standard pipe sizes (outside diameter) [mm] | Minimum overriding nominal thickness [mm] | |
|---|---|---|
| | **Copper** | **Copper alloy** |
| 8 to 10 | 1.0 | 0.8 |
| 12 to 20 | 1.2 | 1.0 |
| 25 to 44.5 | 1.5 | 1.2 |
| 50 to 76.1 | 2.0 | 1.5 |
| 88.9 to 108 | 2.5 | 2.0 |
| 133 to 159 | 3.0 | 2.5 |
| 193.7 to 267 | 3.5 | 3.0 |
| 273 to 457.2 | 4.0 | 3.5 |
| 508 | 4.5 | 4.0 |

3.2.3 Where the minimum thickness calculated by 3.2.1 or 3.2.2 is less than shown in Table 3.2.2, the minimum nominal thickness for the appropriate standard pipe size shown in the Table is to be used. No allowance is required for negative tolerance or reduction in thickness due to bending on this nominal thickness. For threaded pipes, where permitted, the minimum thickness is to be measured at the bottom of the thread.

**3.3 Heat treatment**

3.3.1 Pipes which have been hardened by cold bending are to be suitably heat treated on completion of fabrication and prior to being tested by hydraulic pressure. Copper pipes are to be annealed and copper alloy pipes are to be either annealed or stress relief heat treated.

## Section 4

## Cast Iron Pipes and Fittings

### 4.1 Spheroidal or nodular graphite cast iron

4.1.1 Spheroidal or nodular graphite iron castings for pipes, valves and fittings in Class II and III piping systems are to be made in a grade having a specified minimum elongation not less than 12 per cent on gauge length of $5.65\sqrt{So}$, where So is the actual cross-sectional area of the test piece.

4.1.2 Castings for Class II and III systems, also for ship-side valves and fittings and valves on collision bulkhead, are to be manufactured and tested in accordance with the requirements of acceptable national specifications. A manufacturer's test certificate will be accepted and is to be provided for each consignment of material.

4.1.3 Where the elongation is less than the minimum required by 4.1.1, the material is, in general, to be subject to the same limitations as grey cast iron.

### 4.2 Grey cast iron

4.2.1 Grey cast iron pipes, valves and fittings will, in general, be accepted in Class III piping systems except as stated in 4.2.2.

4.2.2 Grey cast iron is not to be used for the following:

a) Pipes for steam systems and fire extinguishing systems;
b) Pipes, valves and fittings for boiler blow down systems and other piping systems subject to shock or vibration;
c) Ship-side valves and fittings;
d) Valves fitted on collision bulkhead;
e) Clean ballast lines through cargo oil tanks to forward ballast tanks;
f) Bilge lines in tanks;
g) Outlet valves of fuel tanks with static head.

4.2.3 Grey iron castings for piping systems are to comply with acceptable national/international specifications.

## Section 5

## Plastic Pipes

### 5.1 General

5.1.1 Proposals to use plastics material in shipboard piping systems will be considered in relation to the properties of the materials, the operating conditions of temperature and pressure, and the intended service. Any proposed service for plastics pipe not mentioned in these requirements is to be submitted for special consideration.

5.1.2 The specification of the plastics material, including mechanical and thermal properties and chemical resistance data, is to be submitted for consideration.

5.1.3 These requirements are applicable to thermo-plastic pipes but, where appropriate, may also be applied to pipes manufactured in fibre-reinforced thermosetting resins.

5.1.4 Plastics pipes are not to be used where they will be subjected to temperatures above 60°C or below 0°C. Special consideration will be given to particular materials in appropriate applications at higher temperatures.

### 5.2 Applications

5.2.1 Plastics pipes of approved type may be used for the following

services:

a) Air and sounding pipes to tanks used exclusively for carrying water ballast or fresh water, with the exception of the portion above deck;
b) Sounding pipes to cargo holds;
c) Water ballast and fresh water pipes situated inside tanks used exclusively for carrying water ballast or fresh water; and
d) Scupper pipes draining inboard provided they are not led within the boundaries of refrigerated chambers. The first two items (a and b) are not applicable to passenger ships.

5.2.2 Plastics pipes may be used for domestic and similar services for which there are no Rule requirements, such as for the following:

a) Domestic cold sea and fresh water systems;
b) Sanitary systems;
c) Sanitary and domestic waste pipes wholly situated above the freeboard deck; and
d) Water pipes associated with air conditioning plants.

Not withstanding the foregoing, plastics pipes are not to be used in sea water systems where leakage or failure of the pipes could give rise to the danger of flooding.

5.2.3 Since plastics materials are generally heat sensitive and very susceptible to fire damage, plastics pipes will not be acceptable for service essential to safety, such as the following :

a) Fire extinguishing pipes;
b) Bilge pipes in cargo holds;
c) Bilge and ballast pipes in the machinery space;
d) Main and auxiliary water circulating pipes;
e) Feed and condensate pipes; and
f) Pipes carrying oil or other flammable liquids.

### 5.3 Intactness of bulkheads and decks

5.3.1 Where plastics pipes are arranged to pass through watertight or fire- resisting bulkheads or

decks, provision is to be made for maintaining the integrity of the bulkhead or deck in the event of pipe failure. Details of the arrangements are to be submitted for approval.

**5.4 Design and construction**

5.4.1 Pipes and fittings are to be of robust construction and are to comply with the requirements of such national/international standards as may be consistent with their intended use. Particulars of scantlings and joints are to be submitted for consideration.

5.4.2 All pipes are to be adequately but freely supported. Suitable provision for expansion and contraction is to be made in each range of pipes to allow for large movements between plastics pipe and steel structure, the coefficient of thermal expansion for plastics being eight or more times that of steel.

5.4.3 All fittings and branches are to be suitable for the intended service and are to have joints of cemented, flanged or other approved types.

5.4.4 The strength of the pipes and fittings and the acceptability of any jointing system employed is to be check tested at the Surveyor's discretion. The strength of pipes, fittings, joints between pipes and joints between pipes and fittings, as appropriate, is to be determined by hydraulic pressure tests to destruction of sample assemblies. The pressure is to be so applied that failure of the test sample assembly occurs in not less than 5 minutes. Deformation of the pipes and fittings during tests is acceptable.

## Section 6

## Flexible Hoses

**6.1 General**

6.1.1 Short joining lengths of flexible hoses of approved type may be used, where necessary to accommodate relative movement between various items of machinery connected to permanent piping systems.

6.1.2 For the purpose of approval for the applications in 6.2, details of the materials and construction of the hoses, and the method of attaching the end fittings, are to be submitted for consideration.

6.1.3 In general, the use of hose clips as a means of securing the ends of hoses is to be restricted to the engine cooling water system, where the hose consists of a short, straight length joining two metal pipes, between two fixed points on the engine.

6.1.4 Prototype pressure tests are to be carried out on each new type of hose, complete with end fittings, and in no case is the bursting pressure to be less than five times the maximum working pressure in service.

**6.2 Applications**

6.2.1 Synthetic rubber hoses, with integral cotton or similar braid reinforcement, may be used in fresh and sea water cooling systems. In the case of sea water systems, where failure of the hoses could give rise to the danger of flooding, the hoses are to be suitably enclosed.

6.2.2 Synthetic rubber hoses, with single or double closely woven integral wire braid reinforcement, or convoluted metal pipes with wire braid protection, may be used in bilge, ballast, compressed air, fresh water, sea water, fuel oil and lubricating oil systems. Where synthetic rubber hoses are used for fuel oil supply to burners, the hoses are to have external wire braid protection in addition to the integral wire braid.

## Section 7

## Hydraulic Tests on Pipes and Fittings

**7.1 Hydraulic tests before installation on board**

7.1.1 All Class II pipes and their associated fittings are to be tested by hydraulic pressure to the Surveyor's satisfaction. Further, all steam, feed, compressed air and fuel oil pipes, together with their fittings, are to be similarly tested where the design pressure is greater than 0.35 [N/mm$^2$]. The test is to be carried out after completion of manufacture and before installation on board and, where applicable, before insulating and coating.

7.1.2 The test pressure is to be 1.5 times the design pressure.

7.1.3 All valve bodies are to be tested by hydraulic pressure to 1.5 times the nominal pressure rating at ambient temperature. However, the test pressure need not be more than 7 [N/mm$^2$] above the design pressure specified for the design temperature.

**7.2 Testing after assembly on board**

7.2.1 Heating coils in tanks and fuel oil piping are to be tested by hydraulic pressure, after installation on board, to 1.5 times the design pressure but in no case to less than 0.35 [N/mm$^2$].

7.2.2 Where bilge pipes are accepted in way of double bottom tanks or deep tanks, the pipes after fitting are to be tested by hydraulic pressure to the same pressure as the tanks through which they pass.

## Chapter 3

## Pumping and Piping

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### Section 1

### General

**1.1 Scope**

1.1.1 The requirements of this Chapter are applicable to all ships except where otherwise stated.

1.1.2 Piping systems layouts, for which no requirements are given herein, will be specially considered.

**1.2 Plans**

1.2.1 The following plans in diagrammatic form are to be submitted for consideration before proceeding with the work.

a) General arrangement of pumps and piping systems;

b) Fuel oil filling, transfer and service piping systems;

c) Bilge and ballast piping systems;

d) Lubricating-oil piping systems;

e) Liquid cargo pumping systems;

f) Hydraulic power piping systems for essential services;

g) Compressed air piping systems;

h) Steering gear piping systems;

i) Sea water and fresh water service piping systems;

j) Air and sounding piping systems;

k) Steam and feed water piping systems

l) Sanitary piping systems;

m) Fire main and fire extinguishing piping systems.

1.2.2 The plans are to include the information like, wall thickness, maximum working pressure temperature and material of all pipes and type, size and material of the valves and fittings.

**1.3 Materials**

1.3.1 The materials to be used in piping systems are to be suitable for the service intended. In general, except where otherwise stated, pipes, valves and fittings are to be made of steel, cast iron, copper, copper alloy or other approved material.

1.3.2 Cast iron is not to be used for:

a) Shipside and collision bulkhead fittings;

b) Outlet valves of fuel tanks with static head;

c) Bilge and ballast lines passing through double bottom tanks, pipe tunnel and cargo oil tanks;

d) Any piping which can be subjected to shock such as water hammer.

1.3.3 Materials sensitive to heat such as aluminium, lead or plastics, are not to be used in systems essential to the safe operation of the ship.

**1.4 Design pressure**

1.4.1 The design pressure is considered to be, the most severe condition of co-incident pressure and temperature expected in normal operation. For this purpose the maximum difference in pressure between inside and outside of the part is to be considered.

**1.5 Design temperature**

1.5.1 Unless otherwise specified the tempe-rature used in design is to be not less than the mean metal temperature (through the thickness) expected under operating conditions for the part considered.

1.5.2 When sudden cyclic changes in tempe-rature are apt to occur in normal operation with only minor pressure fluctuations, the design is to be governed by the highest probable operating temperature and corresponding pressure.

**1.6 Redundancy**

1.6.1 Redundancy is the ability of a system or a component thereof to maintain or restore its function when one failure has occurred. This can be achieved for instance by installation of more units or alternative means for performing the function.

**1.7 Valves and cocks**

1.7.1 All the valves and cocks are to be so designed and constructed so that the valve covers or glands will not slacken up when the valves are operated.

1.7.2 All the valves are to be designed to close with right hand (clockwise when facing the end of the stem) motion of the wheel of the valve.

1.7.3 All the valves and cocks are to be fitted in places where they are easily accessible at all times and are to be fitted with legible nameplates indicating their function in the system and their installation is to be such that it can be readily observed that they are open or closed.

1.7.4 All the valves and cocks fitted with remote control are to be provided with local manual control independent of the remote operating mechanism. The operation of the local control is not to render the remote control system inoperable.

1.7.5 The valves, cocks and other fittings which are attached directly to plating, which is required to be of watertight construction, are to be secured to the plating by means of studs screwed into the plating and not by bolts passing through clearance holes. Alternatively the studs may be welded to the plating.

**1.8 Shipside fittings (other than sanitary discharges and scuppers)**

1.8.1 All sea inlet and overboard discharge valves are to be fitted in either of the following ways:

a) directly on the shell plating;

b) to the plating of fabricated steel water boxes of rigid construction integral with the ship's plating;

c) to short, rigid distance pieces welded to the shell plating.

1.8.2 Valves for ship-side applications are to be installed such that the section of piping immediately inboard of the valve can be removed without affecting the watertight integrity of the hull.

1.8.3 All valves and cocks fitted directly to the shell plating are to have spigots extending through the plating. These spigot on valves may however be omitted, if valves are fitted on pads which themselves form spigots in way of plating.

1.8.4 Valves and cocks are to be attached to the shell plating by bolts tapped into the plating and fitted with countersunk heads, or by studs screwed into heavy steel pads fitted to the plating. The stud holes are not to penetrate the pad plating.

1.8.5 Ship side valves and fittings, if made of steel or material with low corrosion resistance, are to be suitably protected against wastage.

1.8.6 Gratings are to be fitted at all openings in ship's side for inlet of seawater. The net area through the gratings is to be at least twice the area of the valves connected to the opening.

1.8.7 The scantlings of valves and valve stools fitted with steam, or compressed air clearing connections are to be suitable for the maximum pressure to which the valves and stools may be subjected.

**1.9 Piping installation**

1.9.1 Heavy pipes and valves are to be so supported that their weight is not taken up by connected pumps and fittings.

1.9.2 Support of the pipes is to be such that detrimental vibrations do not arise in the system.

1.9.3 Where pipes are carried through watertight bulkheads or tank tops, means are to be made to ensure the integrity of the watertightness of the compartment.

1.9.4 As far as possible, installation of pipes for water, oil, or steam, is to be avoided near electric switchboards. If this is impracticable, all the joints in pipe line and valves are to be at a safe distance from the switchboards and shielded to prevent damage to switchboard.

1.9.5 Provision is to be made to take care of expansion or contraction stresses in pipes due to temperature stresses or working of the hull.

1.9.6 Expansion pieces of approved type, made of oil resistant re-inforced rubber or other approved material may be used in circulating water systems in machinery spaces.

1.9.7 All piping systems, where a pressure greater than the designed pressure could be developed, are to be protected by suitable relief valves.

1.9.8 All pipes, situated in cargo spaces, fish holds or other spaces, where they can be damaged mechanically, are to be suitably protected.

1.9.9 All pipes which pass through chambers intended for the carriage or storage of refrigerated cargo are to be well insulated. In case the temperature of the chamber is below 0C the pipes are to be insulated from the ship's structure also, except at positions where the temperature of the ship's structure is always above 0°C and is controlled by outside temperature.

Air refreshing pipes leading to and from refrigerated chambers need not be insulated from the ship's structure.

## Section 2

## Bilge and Ballast Piping Systems

### 2.1 General

2.1.1 All ships are to be provided with necessary pumps, suction and discharge piping and means of drainage so arranged that any compartment can be pumped out effectively, when the ship is on an even keel and is either upright or has a list of not more than 5 degrees, through at least one suction, except from machinery spaces where at least two suctions are required, one of which is to be a branch bilge suction and the other is to be a direct bilge suction. Wing suctions will, generally, be necessary for this purpose, except for short narrow compartments, where a single suction may be sufficient.

2.1.2 All passenger ships are to be provided with an efficient bilge pumping plant capable of pumping from and draining any watertight compartment under all practicable conditions after a casualty whether the ship is upright or listed.

2.1.3 Attention is drawn to any relevant statutory requirements of the National Authority of the country in which the ship is to be registered.

### 2.2 Drainage of cargo holds

2.2.1 In ships having only one hold, and this over 30 [m] in length, bilge suctions are to be provided in the fore and after sections of the hold.

2.2.2 In ships having a flat bottom with breadth exceeding 5 [m], bilge suctions are to be fitted at the wings.

2.2.3 Where close ceilings or continuous gusset plates are fitted over the bilges, arrangements are to be made whereby the water in the hold may find its way to the suction pipes.

2.2.4 In ships fitted with double bottoms, suitably located bilge wells are to be provided.

### 2.3 Drainage from fore and aft peaks

2.3.1 Where the peaks are used as tanks, a power pump suction is to be led to each tank, except in case of small tanks (generally not exceeding 2 [$m^3$] used for the carriage of domestic fresh water where hand pumps may be used.

2.3.2 The peaks may be drained by hand pumps provided the peaks are not used as tanks and they are not connected to bilge main. The suction lift is to be well within the capacity of the hand pumps and is not to exceed 7.3 [m].

The after peak may be drained by means of a self closing cock situated in a well lighted and accessible position, and draining into engine room or tunnel.

2.3.3 The collision bulkhead is not to be pierced below the bulkhead deck by more than one pipe for dealing with the contents inside the fore peak tank except as permitted in 2.3.4. The pipe is to be provided with a screw down valve capable of being operated from above the bulkhead deck and the chest of the valve is to be secured to the collision bulkhead inside the tank except as permitted by 2.3.5. An indicator is to be provided to indicate whether the valve is open or shut.

2.3.4 In ships, other than passenger vessels, where the forepeak is divided into two compartments, the collision bulkhead may be pierced by two pipes, i.e. one for each compartment and fitted as in 2.3.3.

2.3.5 In ships other than passenger ships, the valve required by 2.3.3 may be fitted on the after side of the collision bulkhead, provided the valve is readily accessible at all time and is not subject to mechanical damage.

### 2.4 Drainage from tanks, cofferdams and void spaces

2.4.1 All the tanks except self-draining tanks, whether for water ballast, oil fuel, liquid cargoes, etc. are to be provided with suction pipes led to suitable power pumps. The pumping plant is to be so arranged that any water or liquid within any compartment of the ship can be pumped out through at least one suction, when the ship is on an even keel and is either upright or has a list of not more than 5 degrees.

2.4.2 Where the length of the ballast tank exceeds 30 [m], an additional suction is to be provided at the forward end of the tank. Where the width of the tank is unusually large, suctions near the centreline in addition to wing suctions may be required.

2.4.3 Suction pipes from the cofferdams and void spaces are to be led to the main bilge line.

2.4.4 In ships where deep tanks may be used for either water ballast or dry cargo, provision is to be made for blanking the water ballast suction and filling when the tank is being used for carrying cargo and for blanking the bilge line when the tank is being used for carriage of water ballast.

### 2.5 Drainage from spaces above fore and after peaks and above machinery spaces

2.5.1 Provision is to be made for the drainage of chain locker and watertight compartments above the fore peak tank by hand or power pump suctions.

2.5.2 Steering gear compartments or other small enclosed spaces situated above the after peak tank are to be provided with suitable means of drainage, either by hand or power bilge suctions.

2.5.3 If the compartments referred to in 2.5.2 are adequately isolated from the adjacent 'tween decks, they may be drained by scuppers of not less than 38 [mm] bore, discharging into the tunnel (or machinery spaces in case of ships with machinery aft) and fitted with self-closing cocks situated in well lighted and visible positions. These arrangements are not

applicable to passenger ships unless they are specially approved in relation to subdivision considerations.

2.5.4 Accommodation spaces which overhang machinery spaces may also be drained as in 2.5.3.

**2.6 Drainage from machinery spaces**

2.6.1 The bilge drainage arrangements for machinery spaces are to be in accordance with the requirements of 2.1.

2.6.2 In ships in which the propelling machinery is situated at the after end of the ship, it will generally be necessary for the bilge suctions to be fitted in the forward wings as well as in the after end of the machinery space, but each case will be dealt with according to the size and structural arrangements of the compartment.

2.6.3 Where the machinery space is divided into watertight compartments, the drainage system for all compartments except for main engine room is to be same as for cargo holds except that one direct bilge suction from each watertight compartment would also be required.

**2.7 Sizes of bilge suctions**

2.7.1 The internal diameter of the bilge pipes is not to be less than that found by the following formula to the nearest 5 [mm] commercial size available:

a) $d_m = 1.5\sqrt{L(B+D)} + 25$ [mm]

b) $d_m = 2.0\sqrt{C(B+D)} + 25$ [mm]

where,

$d_m$ = internal diameter of bilge main [mm];

$d_b$ = internal diameter of branch bilge [mm];

L = Rule length of ship [m];

B = Moulded breadth of ship [m];

C = Length of the compartment [m];

D = Moulded depth to bulkhead deck [m].

2.7.2 In any case, bilge main suction line and branch bilge suction line diameters are not to be less than 40 [mm] and the diameter of the main bilge line is not be less than that of the branch bilge line.

2.7.3 The internal diameter of the direct bilge suction is not to have less than the main bilge line when connected to a power pump and not less than branch bilge suction when connected to a hand pump.

2.7.4 In oil tankers and similar ships, where the engine room pumps do not deal with bilge drainage outside the machinery spaces, the rule diameter of the bilge main may be reduced provided the proposed cross-sectional area of the bilge main is not less than twice that required for the branch bilge suction in machinery spaces.

2.7.5 The area of each branch pipe connecting the bilge main to a distribution chest is to be not less than the sum of the areas required by the rules for the two largest branch bilge suction pipes connected to that chest, but need not be greater than that required for the main bilge line.

**2.8 Bilge pumps and ejectors**

2.8.1 In ships with main propulsion engines up to 220 [kW] (300 shp), at least one power bilge is to be provided which may be driven by the main engines. In addition hand pump suctions are to be fitted. In ships where the main propulsion engines power exceeds 220 [kW] (300 shp), at least two power bilge pumps are to be provided and at least one of which is to be independently driven. See Annex 4 Chapter 3 for requirements regarding passenger ships.

2.8.2 The capacity of the bilge pump may be found by the following formula:

$$Q = 5.75 \times 10^{-3} \times d^2 \ [m^3/hour]$$

where,

Q = capacity of pump [$m^3$/hour]

d = rule diameter of bilge main [mm].

2.8.3 In ships, other than passenger ships, where one bilge pump is of slightly less than rule capacity, the deficiency may be made good by an excess capacity of the other pump. In general this deficiency is to be limited to 30 percent.

2.8.4 An ejector in conjunction with a sea water pump may be accepted as a substitute for independent power bilge pump. This however, is not acceptable on passenger ships.

**2.9 Pump types**

2.9.1 The bilge pumps required by the rules are to be of self-priming type, unless an approved priming system is provided for these ships.

2.9.2 General service pumps and ballast pumps may be accepted as independent power bilge pumps provided:

a) Their capacity is adequate and in accordance with 2.8.2;

b) These pumps, together with the pipelines to which they are connected, are fitted with necessary devices to ensure that there is no risk of entry of water or oil fuel in the holds or machinery spaces.

**2.10 Bilge piping arrangements and fittings**

2.10.1 Bilge pipes are not, as far as possible, to pass through double bottom tanks. If un-avoidable, such bilge pipes are to be of heavy gauge, with welded joints or heavy flanged joints and are to be tested after fitting to the same pressure as the tanks through which they pass.

2.10.2 The parts of bilge pipes passing through deep tanks, intended to carry water ballast, fresh water,

liquid cargo or fuel oil are normally to be contained in a pipe tunnel, but where this is not done, the pipes are to be of heavy gauge with welded or heavy flange joints. The open ends of such pipes are to be fitted with non-return valves. The pipes are to be tested, after fitting, to a pressure of not less than the maximum head to which the tanks may be subjected.

2.10.3 Expansion bends, not glands, are to be fitted to pipes passing through double bottom tanks or deep tanks.

2.10.4 The intactness of the machinery spaces, bulkheads and of tunnel plating is not to be impaired by fitting of scuppers discharging into machinery spaces or tunnel from adjacent compartments which are situated below the bulkhead deck. These scuppers may, however, be led into a strongly built scupper drain tank situated in the machinery space or tunnel but closed to these spaces and drained by means of a suction of appropriate size led from the main bilge line through a screw-down non-return valve.

a) The scupper tank air pipe is to be led above the bulkhead deck and provision is to be made for ascertaining the level of the water in the tank;

b) Where one tank is used for the drainage of several watertight compartments, the scupper pipes are to be provided with screw-down non-return valves.

2.10.5 No drain valve or cock is to be fitted to the collision bulkhead. Drain valves or cocks are not to be fitted to other watertight bulkheads if alternative means of drainage are practicable. These arrangements are not permissible in passenger ships.

2.10.6 Where drain valves or cocks are fitted to bulkheads other, than collision bulkhead, as permitted by 2.10.5, the drain valves or cocks are to be at all times readily accessible and are to be capable of being shut off from positions above the bulkhead deck. Indicators are to be provided to show whether the drains are open or shut.

2.10.7 Bilge pipes which are required for draining cargo or machinery spaces are to be entirely distinct from sea inlet pipes or from pipes which may be used for filling or emptying spaces where water or oil is carried. This does not, however, exclude a bilge ejection connection, a connecting pipe from a pump to its suction valve chest, or a deep tank suction pipe suitably connected through a change-over device to bilge, ballast or oil line.

2.10.8 The arrangement of pumps, valves and piping is to be such that any pump could be opened up for overhaul and repairs without affecting the operation of the other pumps.

2.10.9 The arrangement of valves, pumps, cocks and their pipe connections is to be such as to prevent the possibility of placing one watertight compartment in communication with another, or of cargo spaces, machinery spaces or other dry spaces coming in communication with the sea or the tanks. For this purpose the bilge suction, pipe of any pump also having sea suction is to be fitted with a non-return valve which cannot permit communication between the bilges and the sea or the compartments in use as tanks.

2.10.10 Screw-down non-return valves are to be provided in the following fittings:

a) Bilge distribution chest valves;

b) Direct bilge suction and bilge pump connection to main line;

c) Bilge suction hose connections on the pumps or on the main line;

d) Emergency bilge suctions.

2.10.11 Bilge suction pipes from machinery spaces and shaft tunnel, except emergency bilge suction, are to be led from easily accessible mud boxes fitted with straight tail pipes to the bilges. The open ends of the tail pipes are not to be fitted with strum boxes. The mud boxes are to be provided with covers which can be easily opened and closed for cleaning purposes.

2.10.12 Strum boxes are to be fitted to the open ends of bilge suction pipes from the cargo holds. The diameter of holes from these strum boxes is not to be more than 10 [mm] and the total area of the holes is not to be less than twice the area of the pipes.

2.10.13 Where access manholes to bilge wells are necessary, they are to be fitted as near to the suction strums as practicable.

2.10.14 Adequate distance is to be provided between the open ends of suction pipes and bilge well bottom to permit adequate and easy flow of water and to facilitate cleaning.

2.10.15 All the valves, cocks and mud boxes are to be located in easily accessible positions above or at the same level as the floor plates. Where this is unavoidable, they may be fitted immediately below the floor plates provided the floor plates are capable of being opened and closed easily and suitable name plates are fitted indicating the fittings below.

2.10.16 Where relief valves are fitted to pumps having sea connections, these valves are to be fitted in readily visible positions above the platform. The arrangement is to be such that any discharge from the relief valves will also be readily visible.

2.10.17 Where non-return valves are fitted to the open ends of bilge suction pipes in cargo holds in order to decrease the risk of flooding, they are to be of an approved type which does not offer undue obstruction to the flow of water.

**2.11 Ballast system**

2.11.1 Provision is to be made for ballasting and deballasting all the ballast tanks by pipe lines which are entirely separate and distinct from pipe lines used for bilging.

2.11.2 Where the length of the ballast tanks exceeds 30 [m], an additional suction is to be provided at the forward end of the tanks. Where the width of the tank is unusually large, suction near the centreline in addition to wing suctions may be required.

## Section 3

## Air and Sounding Piping Systems

### 3.1 General

3.1.1 Reference to oil in this Section is to be taken to mean oil which has a flash point of 60°C or above (closed cup test).

3.1.2 The portions of vent, overflow and sounding pipes fitted above the weather deck are to be of steel.

3.1.3 Name plates are to be affixed to the upper ends of all vent and sounding pipes.

### 3.2 Air pipes

3.2.1 Vent pipes are to be fitted to all tanks, cofferdams, tunnels and other compartments which are not fitted with alternative ventilation arrangements.

3.2.2 The vent pipes are to be fitted at the opposite end of the tank to which the filling pipes are placed and/or at the highest part of the tank and are to be of the self draining type. Where the tank top is of unusual or irregular profile, special consideration will be given to the number and positions of the vent pipes.

3.2.3 Tanks provided with anodes for cathodic protection are to be provided with vent pipes at forward and aft ends.

3.2.4 Vent pipes to double bottom tanks, deep tanks extending to the shell plating or tanks which can be run up from the sea and sea chests are to be run up from the sea and sea chests are to be led above the bulkhead deck.

3.2.5 Vent pipes to oil fuel and cargo oil tanks, cofferdams, all tanks which can be pumped up, shaft tunnels and pipe tunnels are to be led above the bulkhead deck and to open air.

3.2.6 Vent pipes from lubricating oil storage tanks may terminate in the machinery spaces, provided that the open ends are so situated that issuing oil cannot come into contact with electrical equipment or heated surfaces.

3.2.7 The open ends of vent pipes to oil fuel and cargo oil tanks are to be situated where no danger will be incurred from issuing oil or vapour when the tank is being filled.

3.2.8 The open ends of vent pipes to oil fuel, cargo oil and ballast tanks fitted with anodes for cathodic protection, are to be fitted with a wire gauze diaphragm of incorrodible material which can be readily removed for cleaning. The clear area through the wire gauze is to be at least equal to the area of the vent pipe.

3.2.9 In the case of all tanks which can be pumped up either by ship's pumps or by shore pumps through a filling main, the total cross-sectional area of the vent pipes to each tank, or of the overflow pipes where an overflow system is provided, is to be not less than 25 per cent greater than the effective area of the respective filling pipes.

### 3.3 Sounding arrangements

3.3.1 All tanks, cofferdams and pipe tunnels are to be provided with sounding pipes or other approved means for ascertaining the level of liquid in the tanks. Bilges of compartments which are not at all times readily accessible are to be provided with sounding pipes. The soundings are to be taken as near the suction pipes as practicable.

3.3.2 Where gauge glasses are used for indicating the level of liquid in tanks containing lubricating oil, oil fuel or other flammable liquid, the glasses are to be of heat resisting quality, adequately supported, protected from mechanical damage and fitted with self-closing valves at the lower ends and at the top ends if these are connected to the tanks below the maximum liquid level.

3.3.3 Except as permitted by 3.3.4 sounding pipes are to be led to positions above the bulkhead deck which are at all times accessible and in the case of oil fuel tanks, cargo oil tanks and lubricating oil tanks, the sounding pipes are to be led to safe positions on the open deck.

3.3.4 Short sounding pipes may be fitted to double bottom tanks and cofferdams in shaft tunnels and machinery spaces provided the pipes are readily accessible. Short sounding pipes to oil fuel tanks, cargo oil tanks and lubricating oil tanks are not to be placed in the vicinity of boilers, preheaters, heated surfaces, electric generators or motors with commutator or collector rings or electric appliances which are not totally enclosed. The short sounding pipes are to be arranged in such a way that overflow or oil spray will not reach any of machinery components mentioned above. The short sounding pipes are to be fitted with self-closing cocks having cylindrical plugs with weight loaded levers permanently attached and with pedals for opening or other approved arrangements. Short sounding pipes to tanks not intended for oil are to be fitted with screw caps attached by chain to the pipe or with shut off cocks.

3.3.5 In passenger ships, short sounding pipes are permissible only for sounding cofferdams and double bottom tanks situated in the machinery space and are

in all cases to be fitted with self closing cocks as described in 3.3.4.

3.3.6 Striking plates of adequate thickness and size are to be fitted under open ended sounding pipes. Where slotted pipes having closed ends are employed, the closing plugs are to be of substantial construction.

3.3.7 The upper ends of all sounding pipes are to be provided with efficient closing devices. The sounding pipes are to be arranged to be as straight as practicable, and if curved, the curvature is to be large enough to permit easy passage of sounding rod/chain.

## Section 4

## Fuel Oil Systems

### 4.1 General

4.1.1 Oil fuel for machinery and boilers is normally to have a flash point not lower than 60°C (closed cup test). For emergency generator engines, the oil fuel is to have a flash point not lower than 43°C (closed cup test).

4.1.2 Fuels with flash point lower than 60°C may be used in ships intended for service restricted to geographical limits where it can be ensured that the temperature of the machinery and boiler spaces will always be 10°C below the flash point of the fuel. In such cases safety precautions and the arrangements for storage and pumping will be specially considered. However, the flash point of the fuel is not to be less than 43°C unless specially approved.

### 4.2 Oil fuel tanks

4.2.1 Oil fuel tanks are to be separated from fresh water and lubricating oil tanks by means of cofferdams.

4.2.2 Oil fuel tanks are not to be located directly above the highly heated surfaces.

### 4.3 Oil fuel piping

4.3.1 Oil fuel pressure pipes are to be led, where practicable, remote from heated surfaces and electrical appliances, but where this is impracticable the pipes are to have a minimum number of joints and are to be led in well lighted and readily visible positions.

4.3.2 Transfer, suction and other low pressure oil pipes and all pipes passing through oil storage tanks are to be made of cast iron or steel, having flanged joints suitable for a working pressure of not less than 0.69 [N/mm$^2$]. The flanges are to be machined and the jointing material is to be impervious to oil. Where the pipes are 25 [mm] bore or less, they may be seamless copper or copper alloy, except those which pass through storage tanks.

4.3.3 Pipes in connection with compartments storing fresh water are to be separate and distinct from any pipes which may be used for oil or oily water and are not to be led through tanks which contain oil, nor are oil pipes to be led through fresh water tanks.

4.3.4 Pipes conveying vegetable oils or similar cargo oils are not to be led through oil fuel tanks, nor are oil fuel pipes to be led through tanks containing such cargoes.

4.3.5 In passenger ships, provision is to be made for the transfer of oil fuel from any oil fuel storage or settling tank to any other oil fuel storage tank.

### 4.4 Arrangement of valves, cocks, pumps and fittings

4.4.1 The oil fuel and pumping piping arrangements are to be distinct from other pumping systems as far as practicable and the means provided for preventing dangerous interconnection in service are to be thoroughly effective.

4.4.2 All valves and cocks forming part of the oil fuel installation are to be capable of being controlled from readily accessible positions which, in the machinery spaces are to be above the working platform.

4.4.3 Every oil fuel suction pipe from a double bottom tank is to be fitted with a valve or a cock.

4.4.4 For oil fuel tanks which are situated above the double bottom tanks, the inlet and outlet, pipes which are connected to the tank at a point lower than the outlet of the overflow pipe or below the top of the tanks without an overflow pipe, are to be fitted with shut off valves located on the tank itself.

4.4.5 In the machinery spaces valves, mentioned in 4.4.4, are to be capable of being closed locally and from positions outside these spaces which will always be accessible in the event of fire occurring in these spaces. Instructions for closing the valves are to be indicated at the valves and at the remote control positions.

4.4.6 Settling tanks are to be provided with means for draining water from the bottom of the tanks. If the settling tanks are not provided, the oil fuel bunkers or daily service tanks are to be fitted with water drains.

Open drains for removing water from oil tanks are to be fitted with valves or cocks of self-closing type and suitable provision is to be made for collecting the oily discharge.

4.4.7 Where a power driven pump is necessary for transferring oil fuel, a stand by pump is to be provided and connected ready for use, or, alternatively, emergency connections may be made to another suitable power driven pump.

4.4.8 All pumps which are capable of developing a pressure exceeding the design pressure of the system are to be provided with relief valves. Each relief valve is to be in close circuit, i.e. arranged to discharge back to the suction side of the pump and to effectively limit the pump discharge pressure to the design pressure of the system.

4.4.9 Valves or cocks are to be interposed between the pumps on the suction and discharge pipes in order that any pump may be shut off for opening up and overhaul.

4.4.10 Drip trays are to be fitted under all oil fuel appliances which are required to be opened up frequently for cleaning or adjustment.

**4.5 Filling arrangements**

4.5.1 The bunkering of the ship is to be carried out through a permanently fitted pipeline, provided with the required fittings and ensuring fuel delivery to all storage tanks. The open end of the fitting pipe is to be led to the tank bottom.

In passenger ships fuel bunkering stations are to be isolated from other spaces and are to be efficiently drained and ventilated.

4.5.2 Provision is to be made against over-pressure in the filling pipes, and any relief valve fitted for this purpose is to be discharge in to an overflow tank or other safe position.

**4.6 Oil fuel burning arrangements**

4.6.1 Filters are to be fitted in the supply lines to the main and auxiliary machinery. For non-redundant units for essential services, it must be possible to clean the filters without stopping the unit or reducing the supply of filtered oil to the unit.

For auxiliary engines one single oil fuel filter for each engine may be accepted.

4.6.2 Where an oil fuel booster pump is fitted, which is essential to the operation of the main engine(s), a standby pump is to be provided. The standby pump is to be connected ready for immediate use but where two or more main engines are fitted, each with its own pump, a complete spare pump may be accepted provided that it readily accessible and can be easily installed.

4.6.3 Where pumps are provided for fuel valve cooling, the arrangements are to be as in 4.6.2.

**4.7 Remote stop of oil fuel pumps and fans**

4.7.1 Emergency stop of power supply to the following pumps and fans is to be arranged from a central place outside the engine and boiler room:

- oil fuel transfer pump;
- oil fuel booster pump;
- nozzle cooling pumps when oil fuel is used as coolant;
- oil fuel purifiers;
- pumps for oil-burning installations;
- fans for ventilation of engine rooms.

**Section 5**

**Engine Cooling Water Systems**

**5.1 General**

5.1.1 Centrifugal cooling water pumps are to be installed as low as possible in the ship.

**5.2 Cooling water main supply**

5.2.1 Provision is to be made for an adequate supply of cooling water to the main propelling machinery and essential auxiliary engines, also to lubricating oil and fresh water coolers, where these coolers are fitted. The cooling water pump(s) may be worked from the engines or be driven independently.

**5.3 Cooling water standby supply**

5.3.1 Provision is also to be made for a separate supply of cooling water from a suitable independent pump of adequate capacity.

5.3.2The following arrangements are acceptable, depending on the purpose for which the cooling water is intended:

a) Where only one main engine, with power exceeding 370 [kW] (500 shp), is fitted, the standby pump is to be connected ready for immediate use;

b) Where more than one main engine is fitted, each with its own pump, a complete spare pump of each type may be accepted;

c) Where fresh water cooling is employed for main/auxiliary engines, a standby means of cooling need not be fitted if there are suitable emergency connections from a salt water system;

d) Where each auxiliary is fitted with a cooling water pump, standby means of cooling need not be provided for auxiliaries. Where, however a group of auxiliaries is supplied with cooling water from a common system, a standby cooling water pump is to be provided for this system. This pump is to be connected ready for immediate use and maybe a suitable general service pump.

5.3.3 When selecting a pump for standby purposes, consideration is to be given to the maximum pressure which it can develop if the overboard discharge valve is partly or fully closed and, when necessary, condenser doors, water boxes, etc. are to be protected by an approved device against inadvertent over pressure.

**5.4 Relief valves on cooling water pumps**

5.4.1 Where cooling water pumps can develop a pressure head greater than the design pressure of the system, they are to be provided with relief valves on the pump discharge to effectively limit the pump discharge pressure to the design pressure of the system.

**5.5 Sea inlets for cooling water pumps**

5.5.1 Sea-water cooling systems for main and auxiliary machinery are to be connected to at least two cooling water inlets, preferably on opposite sides of the ship.

5.5.2 Where sea water is used for the direct cooling of main engines and auxiliaries, the sea water suction pipes are to be provided with strainers which can be cleaned without interrupting the cooling water supply.

## Section 6
## Lubricating Oil Piping Systems

**6.1 General**

6.1.1 Lubricating oil systems are to be entirely separated from other systems. This requirement, however, does not apply to hydraulic governing and maneuvering systems for main and auxiliary engines.

6.1.2 Lubricating oil tanks are to be separated from other tanks containing water, fuel oil or cargo oil by means of cofferdams.

**6.2 Pumps**

6.2.1 Where lubricating oil for the main engine(s) is circulated under pressure, a standby lubricating oil pump is to be provided where one main engine is fitted and the output of the engine exceeds 370 [kW] (500 shp).

6.2.2 Satisfactory lubrication of the engines is to be ensured while starting and maneuvering.

6.2.3 Similar provisions to those of 6.2.1 and 6.2.2 are to be made where separate lubricating oil systems are employed for piston cooling, reduction gearing, oil operated couplings and controllable pitch propellers, unless approved alternative arrangements are provided. Where the oil glands for stern tubes are provided with oil circulating pump, and the continuous running of this pump is necessary during normal operation, then a standby pump for this purpose is to be provided.

6.2.4 Independently driven rotary type pumps are to be fitted with non-return valves on the discharge side of the pumps.

6.2.4 A relief valve in close circuit is to be fitted on the pump discharge if the pump is capable of developing a pressure exceeding the design pressure of the system, the relief valve is to effectively limit the pump discharge pressure to the design pressure of the system.

**6.3 Control of pumps and alarms**

6.3.1 The power supply, to all independently driven lubricating oil pumps is to be capable of being stopped from a position outside the space which will always be accessible in the event of fire occurring in the compartment in which they are situated, as well as from the compartment itself.

6.3.2 All main and auxiliary engines intended for essential services are to be provided with means of indicating the lubricating oil pressure supply to them. Where such engines and turbines are of more than 75 [kW] (100 shp), audible and visual alarms are to be fitted to given warning of an appreciable reduction in pressure of the lubricating oil supply. Further, these alarms are to be actuated from the outlet side of any restrictions, such as filters, coolers, etc.

**6.4 Filters**

6.4.1 In systems, where lubricating oil is circulated under pressure, provision is to be made for efficient filtration of the oil. For non-redundant units, for essential services, it must be possible to clean the filters without stopping the unit or reducing the supply of filtered oil to the units.

**6.5 Valves and cocks on lubricating oil tanks**

6.5.1 Outlet valves and cocks on lubricating oil service tanks, other than double bottom tanks, situated in machinery spaces are to be capable of being closed locally and from positions outside the space which will always be accessible in the event of fire occurring in these spaces. Remote controls need only be fitted to outlet valves and cocks which are open in normal service and are not required for other outlets such as those on storage tanks.

## Section 7

## Engine Exhaust Gas Piping Systems

**7.1 General**

7.1.1 Where the surface temperature of the exhaust pipes and silencer may exceed 220°C, they are to be water cooled or efficiently lagged.

7.1.2 Where lagging covering the exhaust piping including flanges, is oil-absorbing or may permit penetration of oil, the lagging is to be encased in sheet metal or equivalent. In locations where the Surveyor is satisfied that oil impingement could not occur, the lagging need not be encased.

7.1.3 Exhaust pipes which are led overboard near the waterline are to be protected against the possibility of water finding its way inboard. Where the exhaust is cooled by water spray, the exhaust pipes are to be self-draining overboard.

7.1.4 Exhaust pipes of two or more engines are not to be connected together, but are to be led separately to the atmosphere unless arranged to prevent the return of gases to an idle engine.

7.1.5 In two-stroke engines fitted with exhaust gas turbo-chargers which operate on the impulse systems, provision is to be made to prevent broken piston rings entering the turbine casing and causing damage to blades and nozzle rings.

## Section 8

## Pumping and Piping Systems for Vessels not Fitted with Propelling Machinery

**8.1 Scope**

8.1.1 Following requirements are applicable to vessels not fitted with propelling machinery.

**8.2 Vessels without auxiliary power**

8.2.1 Hand pumps are to be fitted in number and position, as may be required for the efficient drainage of the vessel.

8.2.2 In general, one hand pump is to be provided for each compartment. Alternatively, two pumps connected to a bilge main, having at least one branch to each compartment are to be provided through non-return

valves.

8.2.3 The hand pumps are to be capable of being worked from the upper deck or from positions above the load waterline which are at all times readily accessible. The suction lift is not to exceed 7.3 [m] and is to be well within the capacity of the pump.

8.2.4 The pump capacity is to be based upon the diameter of the suction pipe required for the compartment and as determined in Sec.2.

**8.3 Vessels with auxiliary power**

8.3.1 In vessels in which auxiliary power is available on board, power pump suctions are to be provided for dealing with the drainage of tanks and of the bilges of the principal compartments.

8.3.2 The pumping arrangements are to be as required for self propelled vessels, so far as these requirements are applicable.

## Chapter 4

## Prime Movers and Propulsion Shafting Systems

***Contents***



## Section 1

## General

### 1.1 General

1.1.1 The requirements of this Chapter are applicable to all ships but may be modified for ships intended for special services.

1.1.2 Prime movers of electric generators of less than 50 [kW] capacity, supplying power for lighting loads only, when the ship is in harbour, need not be built under survey.

1.1.3 Attention is drawn to any relevant statutory requirements of the country in which the ship is to be registered.

1.1.4 Power transmission systems not specified in this Chapter will be specially considered.

### 1.2 Materials

1.2.1 Materials intended for the main parts of the prime movers and power transmission systems are to be manufactured and tested in accordance with the requirements of Annex 1.

### 1.3 Primemovers and reduction gearing

1.3.1 Prime movers and reduction gearings are to be designed, manufactured and tested in accordance with the requirements of Designated Authority/Classification Society.

1.3.2 Engines below 100 [kW] including gear boxes used for propulsion and for essential auxiliary machinery may be accepted based on certificate from approved manufacturers. Such engines between 100 [kW] and 300 [kW] are to be type approved. Engines of 300 [kW] and over including gear boxes used for propulsion and for essential auxiliary machinery, are to be type approved and undergo unit certification.

### 1.4 Turning Gear

1.4.1 Arrangements are to be provided to turn the primemover of main propulsion systems and auxiliary drives.

## Section 2

## Main Propulsion Shafting

### 2.1 Scope

2.1.1 The requirements of this Section relate, in particular, to formulae for determining the diameters of shafting for main propulsion installations, but requirements for couplings, coupling bolts, keys, keyways, sternbushes and associated components are also included. The diameter of shafting as calculated may require to be modified as a result of alignment considerations and vibration characteristics (See Sec.8) or the inclusion of stress raisers, other than those contained in this section.

### 2.2 Plans and particulars

2.2.1 The following plans, in triplicate, together with the necessary particulars of the machinery, including the maximum power and revolutions per minute, are to be submitted for approval before the work is commenced:

- Final gear shaft;
- Thrust shaft;
- Intermediate shafting;
- Tube shaft, where applicable;
- Tail shaft;
- Stern bush.

2.2.2 The specified minimum tensile strength of each shaft is to be stated.

2.2.3 A shafting arrangement plan indicating the relative position of the main engines, flywheel, flexible coupling, gearing, thrust block, line shafting and bearings, stern tube, 'A' brackets and propeller, as applicable, is to be submitted for information.

### 2.3 Materials for shafting

2.3.1 The materials are to comply with the relevant requirements of Annex 1 Ch.5. The specified minimum tensile strength of forgings is to be selected within the following general limits :

a) Carbon and carbon-manganese steel - 400-600 [N/mm$^2$]

b) Alloy steels - Not exceeding 800 [N/mm$^2$]

2.3.2 Ultrasonic tests are required on shaft forgings where the diameter is 250 [mm] or greater.

**2.4 Intermediate and thrust shafts**

2.4.1 The diameter, d, of the shaft is to be not less than determined by the following formula :

$$d = 103.5\,k\,a\,\sqrt[3]{\frac{410\,P}{(U+160)\,R}}\ \ [\text{mm}]$$

where,

a = 0.95 for turbine installations, electric propulsion installations and oil engine installations with slip type couplings;

= 1.0 for other oil engine installations;

k = 1.0 for shafts with integral coupling flanges complying with 2.7 or shrink fit couplings;

= 1.10 for shafts with keyways, where the fillet radii in the transverse section of the bottom of the keyway are not to be less than 0.0125 d; after a length of 0.2 d from the end of the keyway, the shaft diameter may be reduced to the diameter calculated with k = 1.0;

= 1.10 for shafts with transverse or radial holes, where the diameter of the hole is not greater than 0.3 d;

= 1.20 for shafts with longitudinal slots having a length of not more than 1.4 d and a width of not more than 0.2 d, where d is calculated with k=1.0;

U = Specified minimum tensile strength of the material [N/mm$^2$]

P = maximum shaft power [kW];

R = Revolutions per minute corresponding to maximum shaft power giving maximum torque.

2.4.2 For shafts with design features other than stated in 2.4.1, the value of k will be specially considered.

**2.5 Tailshafts and tube shafts**

2.5.1 The diameter, $d_p$, of the tailshaft immediately forward of the forward face of the propeller boss or, if applicable, the forward face of the tailshaft flange, is to be not less than determined by the following formula :

$$d_p = 103.5\,k\,a\,\sqrt[3]{\frac{410\,P}{(U+160)\,R}}\ \ [\text{mm}]$$

where,

k = 1.22 for a shaft carrying a keyless propeller, or where the propeller is attached to an integral flange, and where the shaft is fitted with continuous liner or is oil lubricated and provided with an approved type of oil sealing gland;

= 1.26 for a shaft carrying a keyed propeller, and where the shaft is fitted with a continuous liner or is oil lubricated and provided with an approved type of oil sealing gland;

= 1.25 for a shaft carrying a keyless propeller, or where the propeller is attached to an integral flange and is fitted with water lubricated bearings with non-continuous shaft liners;

= 1.29 for a shaft carrying a keyed propeller and is fitted with water lubricated bearings with non-continuous shaft liners;

U = Specified minimum tensile strength of the shaft [N/mm$^2$], but is not to be taken greater than 600 [N/mm$^2$];

P, a and R are defined in 2.4.1.

2.5.2 The diameter, $d_p$ of the tailshaft determined in accordance with the formula in 2.5.1 is to extend over a length not less than that to the forward edge of the bearing immediately forward of the propeller or 2.5 $d_p$ whichever is the greater.

2.5.3 The diameter of the portion of the tailshaft and tubeshaft forward of the length required by 2.5.2 to the forward end of the forward sterntube seal is to be determined in accordance with the formula in 2.5.1 except that:

k = 1.15, when k = 1.22 or 1.26 as required by 2.5.1

k = 1.18, when k = 1.25 or 1.29 as required by 2.5.1

The change of diameter from that required by 2.5.1 to that required by this clause should be gradual.

2.5.4 The taper of the shaft cone is normally not to be steeper than 1:12 on diameter in case of keyed shafts and 1:15 on diameter in case of keyless shafts.

2.5.5 Tailshafts which run in sterntubes and tube shafts may have the diameter forward of the forward stern tube seal gradually reduced to the diameter of the intermediate shaft. Abrupt changes in shaft section at the tailshaft/ tubeshaft to intermediate shaft couplings is to be avoided.

**2.6 Hollow shafts**

2.6.1 For hollow shafts where the bore exceeds 40 per cent of the outside diameter the minimum shaft diameter is not to be less than that given by the following equation :

$$d_o = d\,\sqrt[3]{\frac{1}{1-\left(\frac{d_i}{d_o}\right)^4}}\ \ [\text{mm}]$$

where,

$d_o$ = outside diameter [mm],

d = Rule size diameter of shaft [mm], calculated in accordance with 2.4 or 2.5

$d_i$ = diameter of central hole [mm].

2.6.2 Where the diameter of central hole does not exceed 0.4 times the outside diameter, no increase over Rule size need be provided.

**2.7 Integral couplings**

2.7.1 The thickness of coupling flanges is not to be less than the minimum required diameter of the coupling bolts calculated as in para 2.9, where $U_B$ = U or 0.2 times the rule diameter of the shaft under consideration, whichever is greater.

2.7.2 The fillet radius at the base of the coupling flange is to be not less than 0.08 of the diameter of the shaft at the coupling. The fillets are to have a smooth finish and are not to be recessed in way of nuts and bolt heads.

2.7.3 Where the propeller is attached by means of a flange, the thickness of the flange is to be not less than 0.25 times the actual diameter of the adjacent part of the tailshaft. The fillet radius at the base of the coupling flange is to be not less than 0.125 times the diameter of the shaft at the coupling.

**2.8 Demountable couplings**

2.8.1 Couplings are to be made of steel or other approved ductile material. The strength of demountable couplings and keys is to be equivalent to that of the shaft. Couplings are to be accurately fitted to the shaft.

2.8.2 Hydraulic and other shrink fit couplings will be specially considered upon submittal of detailed pre-loading and stress calculations and fitting instructions. In general, the torsional holding capacity is to be at least 2.8 times the transmitted torque and pre-load stress is not to exceed 70 per cent of the yield strength.

2.8.3 Provision is to be made to resist astern pull.

**2.9 Coupling bolts**

2.9.1 The diameter of the coupling bolts of the fitted type at the joining faces of the coupling is to be not less than that given by the following formula:

$$d_b = \sqrt{\frac{0.427\, d^3 (U + 155)}{N\, D\, U_B}} \quad [\text{mm}]$$

where,

$d_b$ = diameter of the fitted coupling bolts [mm];

d = required diameter [mm] for the shaft in accordance with 2.4 or 2.5 as appropriate calculated by taking the value of k as 1.0;

U = specified minimum tensile strength of the shaft material in [N/mm$^2$];

$U_B$ = specified minimum tensile strength of the bolt material in [N/mm$^2$];

and also $U \le U_B \le 1.7U$;

N = Number of bolts in the coupling;

D = Pitch circle diameter of bolt holes [mm].

2.9.2 The diameter of the non-fitted bolts will be specially considered upon the submittal of detailed pre-loading and stress calculations and fitting instructions.

**2.10 Tailshaft liners**

2.10.1 The thickness, t, of bronze or gunmetal liners fitted on tail shafts, in way of bearings, is not to be less than given by following formula :

$$t = \frac{168 + d_p}{28} \quad [\text{mm}]$$

where,

t = thickness of liner [mm];

$d_p$ = diameter of tail shaft under the liner [mm].

2.10.2 The thickness of the continuous liner between the bearings is not to be less than 0.75t.

2.10.3 Continuous liners are preferably to be cast in one length. If made of several lengths, the joining of the separate pieces is to be made by welding through the whole thickness of liner before shrinking. In general, the lead content of the gunmetal of each length forming a butt welded liner is not to exceed 0.5 per cent. The composition of the electrode or filler rods is to be substantially lead free.

2.10.4 The liners are to withstand a hydraulic pressure of 0.2 [N/mm$^2$] after rough machining.

2.10.5 The liners are to be carefully shrunk or forced upon the shaft by hydraulic pressure, and they are not to be secured by pins.

2.10.6 Effective means are to be provided for preventing water from reaching the shaft at the part between the after end of the liner and the propeller boss.

2.10.7 If the liner does not fit the shaft tightly between the bearing portions in the stern tube, the space between the shaft and the liner is to be filled with a plastic insoluble non- corrosive compound.

**2.11 Keys and keyways**

2.11.1 Round ended or sled-runner ended keys are to be used, and the key ways in the propeller boss and cone of the tail shaft are to be provided with a smooth fillet at the bottom of the keyways. The radius of the fillet is to be at least 0.0125 of the diameter of the tail shaft at the top of the cone. The sharp edges at the top of the keyways are to be removed.

2.11.2 Two screwed pins are to be provided for securing the key in the keyway, and the forward pin is to be placed at least one-third of the length of the key from the end. The depth of the tapped holes for the screwed pins is not to exceed the pin diameter and the edges of the holes are to be slightly beveled.

2.11.3 The distance between the top of the cone and the forward end of the keyway is to be not less than

0.2 of the diameter of the tailshaft at the top of the cone.

2.11.4 The effective sectional area of the key in shear, is to be not less than $\frac{d^3}{2.6 d_1}$ [mm$^2$]

where,

d = diameter [mm], required for the intermediate shaft determined in accordance with 2.4, based on material having a specified minimum tensile strength of 400 [N/mm$^2$];

$d_1$ = diameter of shaft at mid-length of the key [mm].

**2.12 Stern tube and bearings**

2.12.1 The length of the bearing in the sternbush next to and supporting the propeller is to be as follows :

a) For water lubricated bearings which are lined with lignum vitae, rubber composition or staves of approved plastic material; the length is to be not less than 4 times the rule diameter required for the tailshaft under the liner;

b) For bearings which are white-metal lined, oil lubricated and provided with an approved type of oil sealing gland; the length of the bearing is to be approximately twice the rule diameter required for the tailshaft and is to be such that the nominal bearing pressure will not exceed 0.8 [N/mm$^2$]. The length of the bearing is to be not less than 1.5 times its rule diameter;

c) For bearings of cast iron, bronze which are oil lubricated and fitted with an approved oil sealing gland; the length of the bearing is, in general, to be not less than 4 times the rule diameter required for tailshaft;

d) For bearings which are grease lubricated; the length of bearing is to be not less than 4 times the rule diameter required for the tailshaft;

e) For water lubricated bearings lined with two or more circumferentially spaced sectors of an approved plastics material, in which it can be shown that the sectors operate on hydrodynamic principles, the length of the bearing is to be such that the nominal bearing pressure will not exceed 0.55 [N/mm$^2$]. The length of the bearing is not to be less than twice actual diameter of shaft.

2.12.2 Forced water lubrication is to be provided for all bearings lined with rubber or plastics and for those bearings lined with lignum vitae where the shaft diameter is 380 [mm] or over. The supply water may come from a circulating pump or other pressure source. The water grooves in the bearings are to be of ample section and of a shape which will be little affected by weardown, particularly for bearings of the plastic type.

2.12.3 The shut off valve or cock controlling the supply of water is to be fitted direct to the after peak bulkhead, or to the sterntube where the water supply enters the sterntube forward of the bulkhead.

2.12.4 Where a tank supplying lubricating oil to the sterntube is fitted, it is to be located above the load water line and is to be provided with a low level alarm device in the engine room.

2.12.5 Where sternbush bearings are oil lubricated, provision is to be made for cooling the oil by maintaining water in the after peak tank above the level of the sterntube or by other approved means. Means of ascertaining the temperature of the oil in the sternbush are also to be provided.

2.12.6 The oil sealing glands used for sterntube bearings, which are oil lubricated, are to be of approved type.

## Section 3

## Propellers

**3.1 Scope**

3.1.1 The requirements of this Section cover the construction, materials and inspection of propellers.

**3.2 Plans and particulars**

3.2.1 A plan, in triplicate, of the propeller is to be submitted for approval, together with the following particulars:

a) Maximum shaft power, P, in [kW];

b) Revolutions per minute of the propeller at maximum power, R;

c) Propeller diameter, D [m];

d) Pitch at 25 per cent radius (for solid propellers only), $P_{0.25}$ [m];

e) Pitch at 35 per cent radius (for controllable pitch propellers only), $P_{0.35}$ [m];

f) Pitch at 70 per cent radius, $P_{0.7}$, [m];

g) Length of blade section of the expanded cylindrical section at 25 per cent radius (for solid propeller only), $L_{0.25}$, [mm];

h) Length of blade section of expanded cylindrical section art 35 per cent radius (for controllable pitch propellers only) $L_{0.35}$, in [mm];

i) Rake at blade tip measured at shaft axis (backward rake positive, forward rake negative), K, in [mm];

j) Number of blades, N;

k) Developed area ratio, a.

**3.3 Materials**

3.3.1 Castings for propellers and propeller blades are to comply with the requirement of Annex 1 *Ch.8.*

The specified minimum tensile strength is to be not less than stated in Table 3.4.1.

3.3.2 When it is proposed to use materials which are not included in Table 3.4.1, details of the chemical composition, mechanical properties and density are to be submitted for approval.

**3.4 Design**

**3.4.1 Minimum blade thickness**

3.4.1.1 Where the propeller blades are of conventional design, the thickness, t, of the propeller blades at 25 per cent radius for solid propellers, at 35 per cent for controllable pitch propellers, neglecting any increase due to fillets, is to be not less than :

a) For fixed propellers

$$t_{0.25} = 1003 \sqrt{\frac{AP}{C_n\ C R N} + \frac{0.024 B K C_s}{C C_n}} \text{ [mm]}$$

b) For controllable pitch propellers

$$t_{0.25} = 805 \sqrt{\frac{AP}{C_n\ C R N} + \frac{0.015 B K C_s}{C C_n}} \text{ [mm]}$$

where,

$t_{0.25}$ = minimum blade thickness required at 25 per cent radius;

$t_{0.35}$ = minimum blade thickness required at 35 per cent radius;

$C_n$ = Section modulus coefficient at 25 per cent radius or 35 per cent radius as applicable;

$= \frac{I_o}{U_f\ L T^2}$ and is not to be taken greater than 0.10;

$I_o$ = Moment of inertia of the expanded cylindrical section at 25 per cent radius or 35 per cent radius, as applicable, about a straight line passing through the center of gravity parallel to the pitch line or to the nose-tail line, in [mm$^4$];

$U_f$ = maximum normal distance from the moment of inertia axis to points on the face boundary (tension side) of the Section at 25 per cent radius or 35 per cent radius, as applicable [mm];

L = Length of the blade Section of the expanded cylindrical Section at 25 per cent radius or 35 per cent radius, as applicable, [mm];

T = Maximum thickness of the expanded cylindrical Section as approved at 25 per cent or 35 per cent radius, as applicable [mm];

$C_s$ = Section area coefficient at 25 per cent radius or 35 per cent radius as applicable;

$= \frac{a_s}{L T}$

$a_s$ = area of the expanded cylindrical Section at 25 per cent radius or 35 per cent radius, as applicable [mm$^2$];

f = material constant as per Table 3.4.1;

w = material constant as per Table 3.4.1;

a) For fixed-pitch propellers

$$A = 1.0 + \frac{6.0 D}{p_{0.7}} + \frac{4.3 P_{0.25}}{D}$$

$$B = \left(\frac{4300\, w\, a}{N}\right)\left(\frac{R}{100}\right)^2 \left(\frac{D}{20}\right)^3$$

$$C = \left(1 + \frac{1.5 P_{0.25}}{D}\right)\left(L_{0.25}\, f - B\right)$$

b) For controllable pitch propellers

$$A = 1.0 + \frac{6.0 D}{p_{0.7}} + \frac{3.0 P_{0.35}}{D}$$

$$B = \left(\frac{4900\, w\, a}{N}\right)\left(\frac{R}{100}\right)^2 \left(\frac{D}{20}\right)^3$$

$$C = \left(1 + \frac{1.5 P_{0.35}}{D}\right)\left(L_{0.35}\, f - B\right)$$

3.4.1.2 Propellers of unusual design or application will be subject to special consideration upon submittal of detailed stress calculations.

3.4.1.3 Fillets at the root of the blades are not to be considered in the determination of blade thickness.

**Table 3.4.1 : Material constants**

| Materials | Specified min. UTS [N/mm$^2$] | f | w |
|---|---|---|---|
| Manganese bronze Grade Cu 1 | 440 | 22.6 | 8.3 |
| Ni-Manganese bronze Grade Cu 2 | 440 | 22.9 | 8.0 |
| Ni-Aluminium bronze Grade Cu 3 | 590 | 25.7 | 7.5 |
| Mn-Aluminium bronze Grade Cu 4 | 630 | 25.6 | 7.5 |

| | | | |
|---|---|---|---|
| Cast iron | 250 | 11.77 | 7.2 |
| Carbon and low alloy steels | 400 | 14.0 | 7.9 |
| Note: The value of f may be increased by 10 percent for twin screw and outboard propellers of triple screw ships | | | |

**3.4.2 Keyless propellers**

3.4.2.1 Where propellers are fitted without keys, detailed stress calculations and fitting instructions are to be submitted for approval.

**3.4.3 Controllable pitch propellers**

3.4.3.1 In the case of controllable - pitch propellers, means are to be provided to lock the blades in ahead position in case of the failure of the pitch operating mechanism.

3.4.3.2 A propeller pitch indicator is to be fitted at each station from which it is possible to control the pitch of the propeller.

**3.5 Fitting of propellers**

3.5.1 The propeller boss is to be a good fit on the tailshaft cone. The forward edge of the bore of the propeller boss is to be rounded to about 6 [mm] radius.

3.5.2 The exposed part of the tailshaft is to be protected from the action of water by filling all spaces between propeller hub, cap and shaft with a suitable filling material. The propeller assembly is to be sealed at the forward end with a well-fitted soft rubber packing ring. When the rubber ring is fitted in an external gland, the hub counterbore is to be filled with suitable material, and clearances between shaft liner and hub counterbore are to be kept to a minimum. When the rubber ring is fitted internally, ample clearance is to be provided between liner and hub and the ring is to be sufficiently sized to squeeze in to the clearance space when the propeller is driven up on the shaft; and, where necessary, a filler piece is to be fitted in the propeller - hub keyway to provide a flat unbroken seating for the ring. The recess formed at the small end of the taper by the over hanging propeller hub is to be packed with red lead putty or rust-preventing compound before the propeller nut is put on.

3.5.3 Effective means are to be provided to prevent the slackening of the propeller nut.

## Section 4

## Vibrations and Alignment

**4.1 Scope**

4.1.1 The requirements of this Section are applicable to main propulsion systems with power exceeding 200 [kW] and auxiliary machinery systems for essential services with powers exceeding 200 [kW].

4.1.2 Unless otherwise advised, it is the responsibility of the Shipbuilder as the main contractor to ensure, in co-operation with the Engine builders, that the information required by this Section is prepared and submitted.

**4.2 Basic system requirements**

4.2.1 The systems are to be free from excessive torsional, axial and lateral vibration, and are to be aligned in accordance with tolerances agreed with the respective manufacturers.

4.2.2 Where changes are subsequently made to a dynamic system which has been approved, revised calculations are to be submitted for consideration.

**4.3 Resilient mountings**

4.3.1 Where the machinery is installed on resilient mountings, linear vibration (steady state and transient) is not to exceed the limiting values agreed with the manufacturers of the machinery nor those of the resilient mountings.

4.3.2 Misalignment arising from such vibration is not to impose excessive loading on machinery components within the system.

**4.4 Torsional vibration**

4.4.1 Torsional vibration calculations, including an analysis of the vibratory torques and stresses for the dynamic systems formed by the oil engines, turbines, motors, generators, flexible couplings, gearing, shafting and propeller, where applicable, including all branches, are to be submitted for approval together with the associated plans.

4.4.2 Particulars of the division of power developed throughout the speed range for turbines, or from all intended combinations of operation in oil engine installations having more than one engine and/or with power take-off systems are to be submitted.

4.4.3 Any special speed requirements for prolonged periods in service are to be indicated, e.g., range of trawling revolutions per minute, range of operation

revolutions per minute with a controllable pitch propeller, idling speed, etc.

4.4.4 The calculations and/or measurements carried out on oil engine installations containing transmission items sensitive to vibratory torque, e.g. gearing, flexible couplings, or generator rotors and their drives, are to take into account the effects of engine malfunction commonly experienced in service, such as cylinder(s) not firing.

4.4.5 Restricted speed ranges will be imposed in regions of speed where stresses are considered to be excessive for continuous running. Similar restrictions will be imposed, or other protective measures required to be taken, where vibratory torques are considered to be excessive for particular machinery items.

4.4.6 Where calculations indicate the possibility of excessive torsional vibration within the range of working speeds, torsional vibration measurements, using the appropriate recognized techniques, may be required to be taken from the machinery installation for the purpose of determining the need for restricted speed ranges.

**4.5 Axial vibrations**

4.5.1 For all main propulsion shafting systems, the Shipbuilders are to ensure that amplitudes due to axial vibrations are satisfactory throughout the speed range, so far as practicable. Where appropriate, amplitudes may be reduced by the use of suitable vibration dampers or phasing of propeller and engine, etc.

4.5.2 Unless previous experience of similar installation shows it to be unnecessary, calculations of the shafting system are to be carried out. These calculations are to include the effect of the thrust block seating and the surrounding hull structure taking part in the vibration. The result of these calculations or the evidence of previous experience is to be submitted for consideration.

4.5.3 Where calculations indicate the possibility of excessive axial vibration amplitudes within the range of working speeds, measurements using an appropriate recognized technique may be required to be taken from the shafting systems for the purpose of determining the need for restricted speed ranges.

**4.6 Lateral vibrations**

4.6.1 For all main propulsion shafting systems, the Shipbuilders are to ensure that amplitudes due to lateral vibrations are satisfactory throughout the speed range.

4.6.2 Unless previous experience of similar installations shows it to be unnecessary, calculations of lateral, or bending, vibration characteristics of the shafting system are to be carried out. These calculations, taking account of dynamic bearing stiffnesses, are to cover the frequencies giving rise to all critical speeds which may result in significant amplitudes within the speed range, and are to indicate relative deflections and bending moments throughout the shafting system.

4.6.3 The results of these calculations, or the evidence of previous experience, is to be submitted for consideration.

4.6.4 Where calculations indicate the possibility of excessive lateral vibration amplitudes within the range of working speeds, measurements using an appropriate recognized technique may be required to be taken from the shafting system for the purpose of determining the need for restricted speed ranges.

**4.7 Shaft alignment**

4.7.1 For main propulsion installations, the shafting is to be aligned to give acceptable bearing reactions, and bending moments at all conditions of ship loading and operation. The Shipbuilder is to position the bearings and construct the bearing seatings to minimize the effects of movements under all operating conditions.

4.7.2 For geared installations, where two or more pinions are driving the final reduction wheel, calculations are to be submitted to verify that shaft alignment is such that proper bearing reactions are maintained under all operating conditions.

4.7.3 Shaft alignment is to be verified by measurement.

## Chapter 5

## Boilers and Pressure Vessels

*Contents*



## Section 1

## General

### 1.1 Scope

1.1.1 The requirements of this Chapter are applicable to pressure vessels of seamless and fusion welded construction, and their mountings and fittings, for the following uses :

a) Fired boilers;

b) Exhaust gas heated boilers;

c) Economizers, superheaters, reheaters and steam receivers for, and associated with (a) and(b);

d) Steam heated steam generators;

e) Other pressure vessels, not included in (a) to (d).

1.1.2 Consideration will be given to arrangements or details of boilers, pressure vessels and equipment which can be shown to comply with other recognized standards, provided they are not less effective.

### 1.2 Design pressure

1.2.1 The design pressure is the maximum permissible working pressure and is to be not less than the highest set pressure of any safety valve.

1.2.2 The calculations made to determine the scantlings of the pressure parts are to be based on the design pressure, adjusted where necessary to take account of pressure variations corresponding to the most severe operational conditions.

1.2.3 It is desirable that there should be a margin between the normal pressure at which the boiler or pressure vessel operates and the lowest pressure at which any safety valve is set to lift, to prevent unnecessary lifting of the safety valve.

### 1.3 Metal temperature

1.3.1 The metal temperature, T, used to evaluate the allowable stress is to be taken as the actual metal temperature expected under operating conditions for the pressure part concerned, and is to be stated by the manufacturer when plans of the pressure parts are submitted for consideration.

1.3.2 For boilers, the design metal temperature is not to be taken less than the following values, unless justified by an exact calculation of the temperature drop and is in no case to be taken less than 250°C:

a) For steam heated steam generators, secondary drums of double evaporation boilers, steam receivers and pressure parts of fired pressure vessels not heated by hot gases and adequately protected by insulation, the metal temperature, T is to be taken as the maximum temperature of the internal fluid;

b) For pressure parts heated by hot gases, T is to be taken as not less than 25°C in excess of the maximum temperature of the internal fluid;

c) For combustion chambers of the type used in horizontal wet-back boilers, T is to be taken as not less than 50°C in excess of the maximum temperature of the internal fluid;

d) For furnaces, fire boxes, rear-tube plates of dry-back boilers and pressure parts subject to similar rates of heat transfer, T is to be taken as not less than 90°C in excess of the maximum temperature of the internal fluid;

e) For boiler, superheater, reheater and economizer tubes, the design temperature is to be taken as under :

- For boiler tubes the design temperature is to be taken as not less than saturated steam temperature plus 25°C for tubes mainly subject to convection heat, or plus 50°C for tubes mainly subject to radiant heat;
- For superheater and reheater tubes, the design temperature is to be taken as not less than steam temperature expected in the part being considered, plus 35°C for tubes mainly subject to convection heat. For tubes mainly subject to radiant heat the design temperature is to be taken as not less than the steam temperature expected in the part being considered, plus 50°C, but the actual metal temperature expected is to be stated when submitting plans;
- The design temperature for economizer tubes is to be taken as not less than 35°C in excess of the maximum temperature of the internal fluid.

1.3.3 In general, any part of boiler drums or headers not protected by tubes, and exposed to radiation from the fire or to the impact of hot gases, is to be protected by a shield of good refractory material or by other approved means.

1.3.4 Drums and headers of thickness greater than 30 [mm] are not to be exposed to combustion gases having an anticipated temperature in excess of 650°C unless they are efficiently cooled by closely arranged tubes.

**1.4 Plans and particulars**

1.4.1 The following plans, in triplicate, for boiler and pressure vessels are to be submitted for approval, in so far as applicable:

a) General arrangement, including arrangement of valves and fittings;

b) Sectional assembly;

c) Seating arrangements;

d) Steam, water drum and header details;

e) Water wall details;

f) Steam and superheater tubing, including the tube support arrangements;

g) Economizer details;

h) Casing arrangement;

i) Reheat section;

j) Fuel oil burning arrangement;

k) Forced draft system;

l) Boiler mountings including steam stop valves, safety valves and their relieving capacities, feed water connections, blow-off arrangements, watergauges, test cocks, etc.

1.4.2 The plans are to include the following particulars, in so far as applicable :

a) Scantlings;

b) Materials;

c) Weld details;

d) Design pressures and temperatures;

e) Heating surface areas of boilers and superheaters;

f) Estimated pressure drop through superheater;

g) Estimated evaporation rate;

h) Proposed setting pressure of safety valves on steam drum and superheater;

i) Pressure vessel class;

j) Details of heat treatment and testing of welds;

k) Calculations of thicknesses, when required;

l) Test pressures.

**1.5 Classification of pressure vessels**

1.5.1 For Rule purposes, boilers and pressure vessels are graded as shown in Table 1.5.1.

1.5.2 Pressure vessels which are constructed in accordance with the requirements of Class 2 or Class 3 will, if manufactured in accordance with the requirements of a superior class, be approved with the scantlings appropriate to that class.

**Table 1.5.1 : Grading of pressure vessels**

| | Boilers | Steam-heated steam generators | Other pressure vessels |
|---|---|---|---|
| Class 1 | $p > 3.5$ | $D_i > \left(\frac{15}{p} - 1\right)1000$ | $P > 50$ or $t > 38$ |

| | | | |
|---|---|---|---|
| Class 2 | $p \le 3.5$ | $D_i < \left(\frac{15}{p} - 1\right)1000$ | $P \le 50$ or $D_i > \left(\frac{20}{p} - 1\right)1000$ and $16 < t \le 38$ or material temperature > 150°C |
| Class 3 | | | $D_i \le \left(\frac{20}{p} - 1\right)1000$ and $t \le 16$ and material temperature ≤ 150°C |
| Notes: P = design pressure, in bar    $D_i$ = internal diameter [mm]    t = shell thickness [mm] | | | |

1.5.3 In special circumstances relating to service conditions, materials, operating temperature, the carriage of dangerous gases and liquids, etc., it may be required that certain pressure vessels be manufactured in accordance with the requirements of a superior class.

**1.6 Materials**

1.6.1 Materials used in the construction of boilers and pressure vessels are to be manufactured in accordance with the requirements of Annex 1.

1.6.2 The specified minimum tensile strength of carbon and carbon manganese steel plates, pipes, forgings and castings is to be within the following general limits :

a) For seamless and Class 1 and Class 2 fusion welded pressure vessels - 340 - 520 [N/mm$^2$];

b) For boiler furnaces, combustion chambers and flanged plates - 400 - 520 [N/mm$^2$].

1.6.3 The specified minimum tensile strength of low alloy steel plates, pipes, forgings and castings is to be within the general limits of 400 - 500 [N/mm$^2$], and pressure vessels made in these steels are to be either seamless or Class 1 fusion welded.

1.6.4 The specified minimum tensile strength of boiler and superheater tubes is to be within the following general limits :

क) Carbon and carbon-manganese steels - 320 - 460 [N/mm$^2$];

ख) Low alloy steels - 400 - 500 [N/mm$^2$].

1.6.5 Where it is proposed to use materials other than those specified in Annex 1, details of the chemical compositions, heat treatment and mechanical properties are to be submitted for approval. In such cases the values of the mechanical properties used for deriving the allowable stress are to be subject to agreement by Designated Authority.

1.6.6 Where a fusion welded pressure vessel is to be made of alloy steel and approval of the scantlings is required on the basis of the high temperature properties of the material, particulars of the welding consumables to be used, including typical mechanical properties and chemical composition of the deposited weld metal, are to be submitted for approval.

**1.7 Pressure parts of irregular shape**

1.7.1 Where pressure parts are of such irregular shape that it is impracticable to design their scantlings by the application of formulae given in this Chapter, the suitability of their construction is to be determined by hydraulic proof test of a prototype or by an agreed alternative method.

**1.8 Adverse working conditions**

1.8.1 Where working conditions are adverse, special consideration may be required to be given to increasing the scantlings derived from the formulae, e.g. by increasing the corrosion or other allowance at present shown in the formulae, or by adopting a design pressure higher than defined in 1.2, to offset the possible reduction of life in service caused by the adverse conditions. In this connection, where necessary, account should also be taken of any excess of loading resulting from :

a) impact loads, including rapidly fluctuating pressures;

b) weight of the vessel and normal contents under operating and test conditions;

c) superimposed loads such as other pressure vessels, operating equipment, insulation, corrosion-resistant or erosion-resistant linings and piping;

d) reactions of supporting lugs, rings, saddles or other types of supports;

or

e) the effect of temperature gradients on maximum stress.

**1.9 Design**

1.9.1 The boilers and pressure vessels are to be designed in accordance with the requirements of Designated Authority/Classification Society.

**1.10 Manufacture**

1.10.1 The manufacture of boilers and pressure vessels is to be carried out in accordance with the requirements of Designated Authority/Classification Society.

# Chapter 6

# Steering Gears

***Contents***



## Section 1

## General

### 1.1 General

1.1.1 All ships are to be provided with reliable steering systems which would allow the vessel to be steered safely having regard to the use and principal dimensions of the ship. This requirement does not apply to ships intended to be pushed only. Proposals to fit a hand tiller only will receive special consideration.

1.1.2 For ships not fitted with rudders but equipped with steering propellers/nozzles or Voith-Schneider propellers, see 2.5. For ships fitted with rudders, a steering gear is to be provided.

1.1.3 The steering gear is to be secured to the seating by fitted bolts, and suitable chocking arrangements are to be provided. The seating is to be of substantial construction.

1.1.4 The steering gear is to be so designed that the rudder cannot change position when not intended to do so.

1.1.5 Steering gears may be manually operated (steering chains and rods or hand/hydraulic) or fully powered (electric or electric/hydraulic). However, when the rule diameter of the rudderstock exceeds 150 [mm] in way of tiller, a fully powered steering gear is to be provided.

1.1.6 Manually operated gears or power assisted gears are only acceptable when the operation does not require an effort exceeding 16 [kgf] under normal conditions.

1.1.7 If a fully powered steering gear is fitted an independent secondary means of steering is to be provided.

1.1.8 Requirements for chemical tankers, gas carriers and similar vessels will be specially considered.

## Section 2

## Design Criteria

### 2.1 General

2.1.1 The entire steering gear is to be designed, constructed and installed to allow for a permanent transverse list of up to 15 and for ambient temperatures commensurate with the area in which he ship is to operate.

2.1.2 The parts comprising the steering gear are to be so dimensioned that they can withstand all the maximum stresses to which they will be subjected in normal operating conditions. The steering gear is to be sufficiently strong so that in the event of rudder touching the bottom or bank, the maximum damage would be limited to deformation or fracturing of the rudder stock.

2.1.3 The steering gear is to be so designed that a rudder angle of not less than 35 on either side can be obtained.

2.1.4 Where the steering gear is manually operated, on an average one complete turn of the hand wheel is to correspond to at least 3 of rudder angle.

2.1.5 Where the steering gear is fully powered, it is to be capable of turning the rudder at an average rate of 4 degree per second through the entire rudder arc when the rudder is fully immersed and with the ship at full speed.

2.1.6 Where fully powered steering gear is provided with a second, manually operated gear, the latter is to permit the ship to proceed to a mooring at reduced speed.

### 2.2 Fully powered steering gear

2.2.1 Fully powered steering gears may be of the direct electric or electric/hydraulic type.

2.2.2 Powered steering gears are to be fitted with means to limit the torque exerted by the drive.

2.2.3 In case of failure of the main drive and the secondary drive not engaging automatically, it is to be possible to engage the secondary drive by hand at the steering position within 5 seconds, with the rudder in any position.

2.2.4 At the steering station, automatic indication is to be provided as to which drive is in operation.

2.2.5 If the independent secondary drive is manual the power drive is not to actuate the hand wheel. A device is to be fitted to prevent inadvertent turning of

the hand wheel when the manual drive is engaged automatically.

2.2.6 Where the main steering gear is power hydraulically operated whilst the secondary steering is a manually operated hydraulic system, the piping of both systems is to be completely separate, and the main installation is to operate without using the steering wheel pump of the secondary installation.

2.2.7 Where both the main and secondary drive are power hydraulic, the respective pumps must be driven independently.

2.2.8 Where the secondary pump is driven by an engine which does not operate continuously whilst the ship is in motion, means are to be provided to operate the steering gear instantly whilst the emergency engine is gaining the required speed.

2.2.9 The two installations are to have separate pipes, valves, controls, etc. Where the independent functioning of the two installations is ensured, they may have common components.

**2.3 Manual drive**

2.3.1 Where the sole steering installation is a manually operated system, an independent secondary steering system is not required, provided that in the case of a hydraulic system, the dimensioning, construction and layout of the piping precludes deterioration through mechanical action or fire, and the construction of the steering wheel pump ensures faultless operation.

**2.4 Rudder position**

2.4.1 If the position of the rudder(s) is not clearly perceivable from the steering station, a reliable rudder angle indicator is to be provided at the steering station.

2.4.2 Any rudder angle indicator fitted, is to function for both the main and secondary steering gear.

**2.5 Rudder propellers and Voith Schneider equipment**

2.5.1 Where a steering propeller/nozzle or Voith Schneider propeller is fitted, two independent control systems are to be provided between the steering station and the propulsion installation.

2.5.2 Where two or more independent steering propulsion installations are fitted, a secondary independent control system is not required provided the ship remains sufficiently maneuverable in the event of one of the installations failing.

**2.6 Tillers, quadrants and connecting rods**

2.6.1 For the requirements regarding rudder, rudder stock, See Annex 2, Ch.12.

2.6.2 All components transmitting mechanical forces to the rudder stock are to have a strength of at least equivalent to the rudder stock in way of the tiller. The combined resultant stress, $\sigma_e$, caused by the transmission of rudder torque, $Q_r$, in tillers, vanes and other power transmitting components is not to exceed 138 [N/mm$^2$], i.e.

$$\sigma_e = \sqrt{\sigma^2 + 3\tau^2} \le 138 \ [\text{N/mm}^2]$$

where,

$\sigma_e$ = The combined equivalent stress, [N/mm$^2$]

$\sigma$ = The bending stress, [N/mm$^2$]

$\tau$= The torsional shear stress, [N/mm$^2$]

$Q_r$ = The rudder torque [N-m] calculated as per Annex 2, Ch.12, Sec.3.2;

2.6.3 The section modulus 'Z' [cm$^3$] and the sectional area 'A' [cm$^2$] of the tiller arms is not to be less than the following :

$$Z = 0.012\,Q_r \left(1 - \frac{x}{R}\right) [\text{cm}^3]$$

$$A = 2.0\frac{Q_r}{R} \text{x} 10^{-4} \ [\text{cm}^2]$$

where,

R = The distance [m] from the point of application of the effort on the tiller to the centre of rudder stock; and

x = The distance [m] from the section under consideration to the centre of the rudder stock.

2.6.4 The boss may be fitted on the rudder stock by shrinking with/without key or may be of the split type. The ratio between the mean of outer and inner diameters of the boss is to be not less than 1.75 and the height of the boss is not to be less than the inner diameter of the boss.

2.6.5 Co-efficient of friction for shrink fitting is not to be taken greater than 0.17 for dry fitting and 0.15 for oil injection fitting.

2.6.6 In case of split type boss, the total number of joining bolts is to be at least 4. The distance of the centre of the bolts from the centre of the rudder stock is generally to be 1.15du and the thickness of the coupling flange is to be at least 1.1 times the required bolt diameter. The thickness of shim to be fitted between two halves before machining is to be 0.0015du. The diameter of the coupling bolt, $d_b$ is to be not less than :

$$d_b = 0.60\frac{d_u}{\sqrt{n}} \ [\text{mm}]$$

where,

$d_u$ = The rudder stock diameter in way of the tiller calculated in accordance with Annex 2 Ch.12, Sec.3;

n = Total number of joining bolts.

2.6.7 The shear area of the key, As, is not to be less than :

$$A_s = \frac{0.18 Q_r}{d_m} \ [cm^2]$$

where,

$d_m$ = diameter of the conical part of the rudderstock at midway of key, [mm]

The keyway is to extend over the full depth of the tiller and have rounded edges. The abutting surface area of the key, $A_b$, (discounted rounded edges) between the key and the rudder stock or the key and the tiller boss is not to be less than:

$$A_b \geq 0.5\ A_s$$

2.6.8 Where higher tensile bolts are used on bolted tillers and quadrants, the yield and ultimate tensile stresses of the bolt material are to be stated on the plans submitted for approval, together with full details of the methods to be adopted to obtain the required setting-up stress. Where patent nuts or systems are used, the manufacturer's instructions for assembly should be adhered to.

2.6.9 In bow rudders having a vertical locking pin operated from the deck above, positive means are to be provided to ensure that the pin can be lowered only when the rudder is exactly central. In addition, an indicator is to be fitted at the deck to show when the rudder is exactly central.

2.6.10 Steel-wire rope, chain and other mechanical systems, when these are used for rudder stock diameters of 120 [mm] and less but excluding allowance for strengthening in ice, will be specially considered. In general the breaking strength of rods/chains etc. is not to be less than:

$$\text{Breaking strength} \geq 6\ \frac{Q_r}{R}\ [\ N\ ]$$

Where R is defined in 2.6.3.

**2.7 Locking or brake gear and springs**

2.7.1 An efficient locking or brake arrangement is to be fitted to all gears to keep the rudder steady when necessary. In the case of hydraulic steering gears which are fitted with isolating valves on the body of the gear and duplicate power units, an additional mechanical brake need not be fitted.

2.7.2 In bow rudders having a vertical locking pin operated from the deck above, positive means are to be provided to ensure that the pin can be lowered only when the rudder is exactly central. In addition, an indicator is to be fitted at the deck to show when the rudder is exactly central.

2.7.3 The steering gear, unless hydraulically powered, is to be protected by means of springs or buffers from damage by impact on the rudder.

**2.8 Rudder stops**

2.8.1 Suitable stopping arrangements are to be provided for the rudder. Cut-outs on the steering engine are to be arranged to operate at a smaller angle of helm than those for the rudder.

# Chapter 7

## Control Engineering Systems

*Contents*



## Section 1

## General Requirements

### 1.1 General

1.1.1 This Chapter applies to all ships and is in addition to other relevant Chapters of the Rules.

1.1.2 Attention should also be given to any relevant requirements of National, International or Local Authorities which would apply to the ships in service.

1.1.3 This Chapter states requirements for systems of automatic or remote control which may be used for controlling the machinery contained in 1.2.2. The design and installation of other control equipment is to be such that there is no risk of danger due to failure.

1.1.4 The details of control systems will vary with the type of machinery being controlled and special consideration will be given to each case.

### 1.2 Plans

1.2.1 Where control systems are applied to essential machinery or equipment as listed in 1.2.2, plans are to be submitted in triplicate. They are to include or to be accompanied by:

– Details of operating medium, i.e. pneumatic, hydraulic or electric, including standby sources of power.

– Description and/or block diagram showing method of operation.

– Line diagrams of control circuits.

– Lists of points monitored.

– List of alarm points.

– List of control points.

– Test facilities provided.

– Test schedules.

1.2.2 **Control systems**. Plans are required for the following:

– Ballast systems.

– Bilge systems.

– Cargo pumping systems for tankers.

– Controllable pitch propellers.

– Electrical generating plant.

– Fire detection systems.

– Main propelling machinery including essential auxiliaries.

– Steam raising plant.

– Transverse thrust units.

– Steering gear plant.

– Inert gas generators.

1.2.3 **Alarm systems**. Details of the overall alarm system linking engine room, wheelhouse and, where applicable, accommodation spaces are to be submitted.

1.2.4 **Control Station**. Location and details of control station are to be submitted, e.g. control panels.

1.2.5 **Standard system.** Where it is intended to employ a system which has been previously approved, plans may not be required to be submitted.

1.2.6 **Computer based systems**. In addition to documentation specified at 1.2.2 following plans/ documents are to be submitted as applicable:

- System requirement specification
- System block diagram showing details of hardware
- Software quality plans when requested
- Factory acceptance test procedures.

### 1.3 Alarm and control equipment

1.3.1 Major units of equipment associated with control, alarm and safety systems as defined in 1.2 are to be surveyed at the manufacturers' works and the inspection and testing is to be to the Surveyor's satisfaction.

1.3.2 Equipment used in control, alarm and safety systems should be type approved.

1.3.3 Assessment of performance parameters, such as accuracy, repeatability and the like, are to be in

accordance with an acceptable National or International Standard.

**1.4 Alterations or additions**

1.4.1 When an alteration or addition to the approved system(s) is proposed, plans are to be submitted for approval. The alterations or additions are to be carried out under survey, and the inspection, testing and installation is to be to the Surveyor's satisfaction.

1.4.2 Any changes in software are to be submitted for consideration. Where considered necessary, validation tests may be required to be carried out to verify the software performance. Software version changes are to be identified and submitted to surveyor on request.

## Section 2

## Essential Features for Control and Alarm Systems

**2.1 General**

2.1.1 Where it is proposed to install control and alarm systems to the equipment defined in 1.2.2 the applicable features contained in 2.2 to 2.5 are to be incorporated in the system design.

**2.2 Control station(s) for machinery**

2.2.1 A system of alarm displays and controls are to be provided which readily ensure identification of faults in the machinery and satisfactory supervision of related equipment.

**2.3 Alarm system**

2.3.1 Where an alarm system, which will provide warning of faults in the machinery and control systems is installed, the requirements of 2.3.1 to 2.3.10 are to be satisfied.

2.3.2 Machinery and control system faults are to be indicated at the relevant control station to advise duty personnel of a fault condition.

2.3.3 Individual alarm channels may be displayed as group alarms at the main control station (if fitted) or alternatively at subsidiary control stations.

2.3.4 All alarms are to be both audible and visual. If arrangements are made to silence audible alarms they are not to extinguish visual alarms.

2.3.5 If an alarm has been acknowledged and a second fault occurs before the first was rectified then audible and visual alarms are again to operate.

2.3.6 Failure of the power supply to the alarm system is to be indicated.

2.3.7 The alarm system should be designed with self-monitoring properties. As far as practical, any fault in the alarm system should cause it to fail to the alarm condition.

2.3.8 The alarm system is to be designed as far as practical to function independently of control systems, such that a failure or malfunction in these systems will not prevent the alarm from operating.

2.3.9 Disconnection or manual overriding of any part of the alarm system should be clearly indicated.

2.3.10 The alarm system is to be capable of being tested.

2.3.11 The alarm system is to be designed with self-monitoring capabilities.

2.3.12 In wheelhouse illumination of all indications and controls are to be provided with dimming facility.

**2.4 Control systems**

2.4.1 Control systems for machinery operations are to be stable throughout their operating range.

2.4.2 Failure of the power supply to a control system for propulsion machinery and associated systems is to operate an audible and visual alarm.

2.4.3 When remote or automatic controls are provided, sufficient instrumentation is to be fitted at the relevant control stations to ensure effective control and indicate that the system is functioning correctly.

2.4.4 Where valves are operated by remote or automatic control, the system of control should include the following safety features:

(a) Failure of actuator power should not permit a closed valve to open inadvertently.

(b) Positive indication is to be provided at the remote control station for the service to show the actual valve position or alternatively that the valve is fully open or closed. Valve position indicating systems are to be of an approved type.

(c) Equipment located in places which may be flooded should be capable of operating when submerged.

(d) A secondary means of operating the valves, which may be local manual control is to be provided.

**2.5 Computer based systems**

2.5.1 The requirements specified in this sub-section are to be complied with for equipment, which are intended to be used for essential services and safety critical equipment, which incorporate computer based systems.

2.5.2 Computer based systems are to be provided with self-monitoring facilities

2.5.3 Systems is to revert to a defined safe state on initial startup or restart in the event of failure.

2.5.4 In the event of failure of any programmable electronic equipment the system is to fail to a defined safe state or maintain safe operation, as applicable.

2.5.5 Where software is used for control of essential equipment, the software is to be certified towards software quality assurance.

2.5.6 Alternate means of back-up fully independent and hard wired are to be provided. Alternatively, if they are dependent on software then the software is to be certified by Designated Authority/Classification Society towards software quality assurance.

2.5.7 Failure of power supply is to initiate an alarm.

2.5.8 Emergency stop systems are to be hard wired and where they are implemented through computer based system, then the software is to be certified by Designated Authority/Classification Society.

2.5.9 Essential equipment in integrated system are to be able to operate independently.

2.5.10 Failure of one part of integrated system is not to affect the functionality of other parts of the integrated system.

**2.6 Fire detection alarms systems**

2.6.1 Where an automatic fire detection system is to be fitted in a machinery space the requirements of 2.6.2 to 2.6.9 are to be satisfied.

2.6.2 A fire detector indicator panel is to be located in such a position that a fire in the machinery spaces will not render it inoperative.

2.6.3 The audible fire alarm is to have a characteristic tone which distinguishes it from any other alarm system. The audible fire alarm is to be audible on all parts of the bridge and in the accommodation areas.

2.6.4 The alarm system should, so far as practicable, be designed with self-monitoring properties.

2.6.5 Failure of power supply to the alarm system is to be indicated.

2.6.6 Detector heads of an approved type are to be located in the machinery spaces so that all potential fire outbreak points are guarded.

2.6.7 The fire detection system is to be capable of being tested.

2.6.8 It is to be demonstrated to the Surveyor's satisfaction that detector heads are so located that air currents will not render the system ineffective.

2.6.9 A drawing showing the location of the fire detector heads and the fire indicator panel, is to be submitted.

## Section 3

## Control and Supervision of Machinery

**3.1 General**

3.1.1 When machinery, as defined in 1.2.2, is fitted with automatic or remote controls so that under normal operating conditions it does not require any manual intervention by the operators then it is to be provided with the arrangements specified in 3.2 to 3.7. Alternative arrangements which provide equivalent safeguards will be considered.

**3.2 Oil engines for propulsion purposes**

3.2.1 The following systems are to be provided with alarms:

| System | Alarm |
|---|---|
| Lubricating oil pressure for the engine including gearing | Low |
| Lubricating oil pressure for the engine including gearing | Failure, see 3.2.2 |
| Cooling system(s) temperature | High |
| Cooling system(s) temperature | Excessively high, see 3.2.3 |

3.2.2 In the case of the lubricating oil system, in addition to the alarm indication as required by 3.2.1, at complete loss of lubricating oil the engine is to be stopped automatically or alternatively a second and separate alarm is to be provided giving audible and visible warning in the wheelhouse and in the engine room. The circuit and sensor employed for this automatic stop or alarm are to be additional to the alarm circuit and sensor required by 3.2.1.

3.2.3 In the case of cooling system(s), in addition to the alarm indication as required by 3.2.1, a shutdown system for excessively high temperatures may be fitted, which is to be independent of the alarm system.

3.2.4 Prolonged running in a restricted speed range is to be prevented automatically; alternatively, indication of restricted speed ranges is to be provided at each control station.

**3.3 Boilers**

3.3.1 A system of water level detection is to be fitted which will operate alarms and shut off automatically the oil supply to the burners when the water level falls to a predetermined low level.

3.3.2 The oil fuel is to be shut off automatically from the burners, and alarms are to operate on flame failure and failure of combustion air supply detected by either low pressure at the fan outlet or stopping of the fan motor.

3.3.3 Where the burner flame(s) is/are extinguished and reignited automatically in response to steam demand then after total flame failure re-ignition shall not take place until the furnace has been purged of explosive gases.

**3.4 Auxiliary engines**

3.4.1 The following systems for auxiliary engines of more than 37 kW (50 shp) are to be provided with alarms:

| System | Alarm |
|---|---|
| Lubricating oil pressure | Low * |
| Cooling system temperature | High * |
| * These alarms may be combined with an automatic shutdown system, if fitted | |

**3.5 Remote control for propulsion machinery**

3.5.1 The following systems are to be provided with alarms:

| System | Alarm |
|---|---|
| Operating medium for hydraulic or pneumatic coupling in propulsion system | Low pressure |
| Operating medium for hydraulic or pneumatic remote control system for main engine | Low pressure |
| Electrical supply to remote control system for main engine | Loss of supply |

**3.6 Controllable pitch propellers and trans-verse thrust units**

3.6.1 Preferred alarms and safeguards are indicated in 3.6.2 to 3.6.4.

3.6.2 In the case of main propulsion systems, means are to be provided to prevent the engines and shafting being subjected to excessive torque due to changes in propeller pitch, alternatively an engine overload indicator may be fitted at each station for which it is possible to control the pitch of the propeller.

3.6.3 Where transverse thrust units are remotely controlled, means are to be provided at the remote control station to stop the propulsion

unit.

3.6.4 The following systems are to be provided with alarms:

| System | Alarm |
|---|---|
| Hydraulic system pressure | Low |
| Power supply to the control system between the remote control station and hydraulic actuator | Loss of supply |

**3.7 Steering gear**

3.7.1 For power operated steering gear, safeguards and alarms are to be provided as indicated in 3.7.2 and 3.7.5.

3.7.2 Provision should be made at the bridge to ensure that the steering gear may be rapidly and effectively transferred to an alternative power and control system, which may be manual.

3.7.3 Where the alternative steering gear system is also power operated this system should be independent of the main power system.

3.7.4 The control system for the alternative steering gear system required by 3.7.2 is to be independent of the main steering gear control system.

3.7.5 The following systems are to be provided with alarms:

| System | Alarm |
|---|---|
| Steering gear power system(s) | Failure |
| Steering gear control system(s) | Failure |
| Steering gear hydraulic oil tank level | Low |

**3.8 Main propulsion shafting**

3.8.1 Where a tank supplying lubricating oil to the sternbush is fitted, it is to be located above the load waterline and is to be provided with a low level alarm.

## Chapter 8

## Electrical Installations - Equipment and Systems

***Contents***



## Section 1

## General Requirements

### 1.1 General

1.1.1 The requirements of this Chapter apply to self-propelled and non self-propelled ships for service on inland waterways unless otherwise stated.

1.1.2 In passenger ships, services essential for safety are to be maintained under emergency conditions and the safety of ship and personnel from electrical hazards is to be assured.

1.1.3 Electrical installations are to be constructed and installed in accordance with the relevant sections of this Chapter and are to be inspected and tested by the Surveyors. Compliance with the requirements of an acceptable National or International Standard may be accepted as meeting the requirements of this Chapter, subject to inspection and testing by the Surveyors.

1.1.4 Consideration will be given to the electrical arrangements of small ships and ships to be assigned class notation for a specified limited service.

1.1.5 In addition to the requirements of this Chapter, vessels using batteries as the main and/ or additional source of power for propulsion are also to be in accordance with requirements of Designated Authority/Classification Society.

### 1.2 Plans

1.2.1 The plans and particulars in 1.2.2 to 1.2.4 are to be submitted in triplicate for approval.

1.2.2 **Electrical Equipment**: The arrangement plan and circuit diagram of the switchboard(s). Diagrams of the wiring system including cable sizes, type of insulation, normal working current in the circuits and the capacity, type and make of protective devices. Calculations of short circuit currents at main busbars and the secondary side of transformers are to be submitted.

1.2.3 **Oil tankers, and similar vessels**: A general arrangement of the ship showing hazardous zones or spaces and the location of electrical equipment in such zones or spaces. A schedule of safe type electrical equipment located in hazardous zones or spaces giving details of the type of equipment fitted, the Certifying Authority, the certificate number and copies of the certificate.

1.2.4 **Centralised, remote or automatic controls:** See Ch.7.

### 1.3 Additions or alterations

1.3.1 Additions or alterations, (temporary or permanent) to the approved load of an existing installation are not to be made until it has been ascertained that the current carrying capacity and the condition of the existing accessories, conductors and switchgear are adequate for the proposed modification.

1.3.2 Plans for the proposed modifications are to be submitted for approval and the alterations or additions are to be carried out under the inspection, and to the satisfaction of the Surveyors.

### 1.4 Application

1.4.1 Except where a specific statement is made to the contrary, all requirements of this Chapter are applicable to both alternating current and direct current installations.

1.4.2 Direct current equipment is to operate satisfactorily under voltage fluctuations of plus 6 per cent and minus 10 per cent.

1.4.3 Alternating current equipment is to operate satisfactorily under voltage fluctuations of plus 6 per cent and minus 10 per cent at rated frequency, and

under frequency fluctuations of ± 5 per cent at rated voltage.

1.4.4 Contactors and similar electromagnetic equipment are not to drop out at or above 85 per cent rated voltage.

1.4.5 For D.C. installations supplied by batteries, consideration is to be given to the supply voltage variations between the battery's full charged and minimum charged voltages. For installations with float charging, the maximum charging voltage is also to be considered.

**1.5 Ambient reference conditions**

1.5.1 The rating of electrical equipment is to be suitable for the temperature conditions associated with the geographical limits of the intended service. See also Ch.1.

**1.6 Location and construction**

1.6.1 Electrical equipment is to be placed in accessible and adequately lighted spaces clear of flammable material and heat sources. The spaces should be well ventilated, and the equipment should not be exposed to risk of mechanical injury or damage from water, excessive moisture, steam, oil or any other dangerous fluid. Where necessarily exposed to such hazards, the equipment is to be suitably constructed or enclosed.

1.6.2 Live parts are to be efficiently shielded from any accidental contact.

1.6.3 All electrical apparatus and equipment is to be constructed and installed so as to avoid injury or electrical shock when handled or touched in the course of normal operation.

1.6.4 All nuts and bolts/screws used to connect or secure current- carrying parts and working parts are to be effectively locked, to prevent them from working loose during operation.

**1.7 Earthing**

1.7.1 All non-current-carrying exposed metal parts of electrical machines or equipment are to be effectively earthed.

1.7.2 All accessible non-current-carrying metal parts of portable electrical apparatus rated in excess of 55 volts are to be earthed through a suitable conductor unless equivalent safety provisions are made such as by double insulation or by an isolating transformer.

1.7.3 In general earthing connections are to be equal to the cross section of the current-carrying conductor up to 16 [$mm^2$]. Above this figure they are to be equal to at least half the cross section of the current carrying conductor with a minimum of 16 [$mm^2$]. Earthing connections which are not made of copper are to have a conductance not less than that specified for a copper earthing connection. These are to be securely installed and protected where necessary against mechanical damage and electrolytic corrosion. These are to be made in an accessible location and secured at both ends by corrosion resistant screws or clamps with cross section corresponding to the earth conductor. Such screws or clamps are not to be used for other purposes. Suitable washers and conductor terminals are to be used so that a reliable contact is ensured.

1.7.4 The metallic sheaths of cables other than the measuring circuits are to be earthed at their two ends.

**1.8 Creepage and clearance**

1.8.1 Distance between live parts and between live parts and earthed metal, whether across surfaces or in air, are to be adequate for the working voltages considering the nature of the insulating material and the transient over voltages developed by switch and fault conditions.

**1.9 Electrical equipment for use in explosive gas atmospheres**

1.9.1 Where the Rules require electrical equipment to be of a "safe type", such equipment is to be certified for the gases/vapours involved. The equipment should conform to IEC publication 79, "Electrical Apparatus for Explosive Gas Atmospheres", or an equivalent national standard.

1.9.2 Copies of type test certificate by a competent independent Testing Authority are to be made available.

1.9.3 When "safe type" equipment is permitted in hazardous zones or spaces all switches and protective devices are to interrupt all lines or phases and, where practicable, are to be located in a non-hazardous zone or space unless specifically permitted otherwise. Appropriate labels of non-flammable material are to be permanently affixed to such equipment, switches and protective devices for identification purposes.

## Section 2

## System Design

**2.1 Design**

**2.1.1 Supply and distribution systems**

2.1.1.1 The following systems of generation and distribution are acceptable for parallel systems at constant voltage (refer Table 2.1.1 for details):-

क) d.c. two-wire insulated,

ख) a.c. single-phase two-wire insulated,

ग) a.c. three-phase, three-wire insulated,

घ) a.c. three-phase, four-wire with neutral earthed but without hull return.

System voltages for both alternating current and direct current are not to exceed:

- 500 V for generation, power, cooking and heating equipment permanently connected to fixed wiring.
- 250 V for lighting, heaters in cabins and public rooms, and other applications not mentioned above.

2.1.1.2 Systems of generation and distribution, having voltages other than those specified above, will, upon application, be given special consideration.

**Table 2.1.1 : Systems of generation and distribution**

| Description | Tankers intended for the carriage in bulk of oil, liquefied gases and other hazardous liquids having a flashpoint not exceeding 60°C (closed cup test) | Other vessels |
|---|---|---|
| d.c. two wire insulated system (See Note 1) | Acceptable | Acceptable |
| a.c., single-phase, two wire insulated system (See Note 1) | Acceptable | Acceptable |
| a.c., three-phase, three wire insulated system (See Note 2) | Acceptable | Acceptable |
| a.c. or d.c. earthed systems | Normally not acceptable (See Note 3) | Acceptable |
| a.c. three-phase, four wire system with neutral earthed but without hull return | Not acceptable | Acceptable upto 1000V |
| Hull return system of distribution (a.c. or d.c.) | Normally not acceptable<br>(See Notes 4 and 5) | Normally not acceptable<br>(See Notes 4 and 5) |

**Note 1** : None of the poles/phases is earthed (see also para 2.1.2).

**Note 2** : Neutral is not earthed.

Note 3 : This may be acceptable for -

क) Power supplied control circuits and instrumentation circuits, where technical or safety reasons require connection to earth, provided the current in the hull is limited to not more than 5 amps in both normal and fault conditions.

ख) Earthed intrinsically safe circuits.

ग) Limited and locally earthed systems, provided that any possible resulting current does not flow directly through any of the dangerous spaces.

Note 4 : This may be acceptable for -

क) Impressed current cathodic protection systems.

ख) Limited and locally earthed systems, such as starting and ignition systems of internal combustion engines, provided that any possible resulting current does not flow directly through any of the dangerous spaces.

ग) Insulation level monitoring devices, provided the circulation current does not exceed 30 mA under the most unfavourable conditions.

**Note 5 :** All final sub-circuits, i.e. all circuits fitted after the last protective device are to be of two insulated wires the hull return being achieved by connecting to the hull, one of the busbars of the distribution board from which wires originate.

**2.1.2 Earth indication**

2.1.2.1 Every insulated distribution system is to be provided with lamps or other devices to indicate the state of electrical insulation from earth and to give an alarm in case of abnormally low insulated values. Where lamp indicators are used, the lamps are to be

of the metal filament type and their power is not to exceed 30 watts.

**2.1.3 Number and rating of generating sets**

2.1.3.1 The number and rating of service generating sets are to be adequate to ensure the operation of services essential for the propulsion and safety of the ship. The power source can be in the form of:

a) two diesel alternator sets

b) one diesel generator and battery. The battery is to be capable of supplying all essential services for a period of at least 30 minutes. Means are to be provided to charge the batteries even when main engine is stationary.

**Note**: Generator driven by main propulsion unit is accepted as main source of power provided that a battery source is arranged in 2.1.3.1 (b) as back up source. The generator voltage is to regulated.

2.1.3.2 On oil tankers and similar vessels, where electrical power is required for essential equipment, the generating plant and converting plant is to be of such capacity that this essential equipment can be operated satisfactorily even with one generating set or converting set out of action.

**2.1.4 Essential services**

2.1.4.1 Where essential services are duplicated, they are to be served by individual circuits separated throughout their length as widely as is practicable and without the use of common feeders, protective devices or control circuits.

**2.1.5 Diversity factor**

2.1.5.1 Circuits supplying two or more final sub-circuits are to be rated in accordance with the total connected load subject, where justified, to the application of a diversity factor. Where spare ways (feeders) are provided on a section or distribution board, an allowance for future increase of load is to be added to the total connected load before application of any diversity factor.

2.1.5.2 The diversity factor may be applied when calculating cable size and when calculating the rating of switchgear and fusegear.

2.1.5.3 The diversity factors are not applicable to supply cables to distribution switchboards for lighting and heating.

**2.1.6 Lighting circuits**

2.1.6.1 Lighting circuits are to be supplied by final sub-circuits, which are separate from those for heating and power. This provision need not be applied to cabin fans and small wardrobe heaters.

2.1.6.2 A final sub-circuit of rating exceeding 15 amperes is not to supply more than one point.

2.1.6.3 A final sub-circuit of rating 15 amperes or less is not to supply more than the following number of lighting points:-

| | |
|---|---|
| 10 | for 24 - 55 V circuits |
| 14 | for 110 - 127 V circuits |
| 18 | for 220 - 250 V circuits |

This provision is not applicable to final sub-circuits for cornice lighting, panel lighting and electric signs where lampholders are closely grouped. In such cases, the number of points is unrestricted provided the maximum operating current in the sub-circuit does not exceed 10 amperes.

2.1.6.4 Lighting of unattended spaces, such as cargo spaces is to be controlled by multi-pole linked switches located outside such spaces. Provision is to be made for the complete isolation of these circuits and locking in the "OFF" position of the means of control.

2.1.6.5 Emergency lighting where required to be provided for passenger vessels, is to be fitted in accordance with Part 5, Chapter 3.

2.1.6.6 Where more than one light is installed in a space, the lighting is to be supplied from at least two final sub-circuits in such a way that failure of one of the circuits does not leave the space in darkness.

2.1.6.7 In general, main and emergency lighting are to be provided at the following locations, where required by the Rules/ statutory authorities, as applicable:

(a) at all stowage and designated preparation positions for life-saving appliances;

(b) at all muster stations and, where applicable, embarkation stations and over sides;

(c) escape route alleyways, stairways and exits;

(d) accommodation areas, cabins and personnel lift cars;

(e) in other areas intended for use by persons with reduced mobility;

(f) in the machinery spaces and main generating stations, including their control positions and their exits;

(g) in the wheelhouse;

(h) at all stowage positions for fireman's outfits.

**2.1.7 Motor circuits**

2.1.7.1 A separate final sub-circuit is to be provided for every motor required for essential services and for every motor of 1 [kW] or more.

**2.1.8 Motor control**

2.1.8.1 Every electric motor is to be provided with an efficient means of starting and stopping so placed as to be easily accessible to the person controlling the motor.

2.1.8.2 Every motor required for essential services and every motor of 0.5 [kW] or more is to be provided with the control apparatus as mentioned in 2.1.8.4 to 2.1.8.8.

2.1.8.3 When motor control gear is being selected, the maximum current of the motor is to be taken as its rated full load current.

2.1.8.4 Efficient means of isolation are to be provided so that all voltage may be cut off from the motor and any associated apparatus including any automatic circuit breaker.

2.1.8.5 Where the primary means of isolation (viz. that provided at the switchboard, section board or distribution fuse board) is remote from a motor, one of the following provisions is to be made :-

क) An additional means of isolation fitted adjacent to the motor; or

ख) Provision made for locking the primary means of isolation in the OFF position; or

ग) Provision made so that the fuses in each line can be readily removed and retained by authorized personnel.

2.1.8.6 Means to prevent the undesired restarting after a stoppage due to low volts or complete loss of volts are to be provided. This does not apply to motors where a dangerous condition might result from the failure to restart automatically e.g. steering gear motor. It is, however, to be ensured that the total starting current of motors having automatic re-start will not cause excessive voltage drop or overcurrent on the installation.

2.1.8.7 Means for automatic disconnection of the supply in the event of excess current due to mechanical overloading of the motor are to be provided. (This does not apply to steering gear motors).

2.1.8.8 Where fuses are installed to protect polyphaser motor circuits, means are to be provided to protect the motor against unacceptable overload in the case of single phasing.

**2.1.9 Remote stops for ventilation fans and pumps**

2.1.9.1 Ventilating fans for machinery and cargo spaces are to be provided with means for stopping them from easily accessible control stations located outside such spaces.

2.1.9.2 Motors driving forced and induced draught fans, independently driven pumps delivering oil to main propulsion machinery for bearing lubrication and piston cooling, oil fuel transfer pumps, oil fuel unit pumps and other similar fuel pumps, fuel and lubricating oil purifiers and their attached pumps are to be fitted with remote controls situated outside the space concerned so that the electrical supply thereto can be disconnected in the event of fire arising in the space in which they are located.

2.1.9.3 In passenger ships all power ventilation systems, except cargo and machinery spaces ventilation, which is to be in accordance with 2.1.9.1, are to be fitted with master controls so that all fans may be stopped from either of two separate positions which are to be situated as far apart as practicable.

**2.1.10 Steering gear**

2.1.10.1 Where electrical control of the steering system is fitted, an independent alternative control system is to be installed. This may be a duplicate electrical control system or control by other means.

2.1.10.2 Provision is to be made on the bridge to transfer the steering control instantaneously to the alternative means of control.

2.1.10.3 Indicators for running indication of steering gear motors are to be installed on the bridge.

2.1.10.4 Audible and visual alarms are to operate at the steering positions for failure of steering gear power system and failure of steering gear control system.

**2.1.11 Fire detection, alarm and extinguishing systems on passenger ships**

2.1.11.1 Where electrically driven emergency fire pumps are installed in accordance with Ch.9 the supply to such pumps is not to pass through the main machinery space.

2.1.11.2 Any fire alarm system is to operate both audible and visual signals at the fire detection control station(s).

**2.1.12 Navigation lights**

2.1.12.1 Each navigation light is to be controlled and protected in each insulated pole by a switch and fuse or circuit breaker mounted in the distribution board.

2.1.12.2 Automatic indication of failure is to be provided unless the lights are visible from the bridge.

2.1.12.3 Any statutory requirements of the country of registration are to be complied with and may be accepted as an alternative to the above.

**2.1.13 Size of batteries and charging facilities**

2.1.13.1 Where batteries are used for starting main engines, they are to be of adequate capacity to meet the requirements of Ch.4.

2.1.13.2 Adequate charging facilities are to be provided, and where batteries are charged from line voltage by means of a series resistor, protection against reversal of current is to be provided when the charging voltage is 20 per cent of line voltage or higher. Means are also to be provided to isolate the batteries from the low voltage system when being charged from a higher voltage system.

**2.1.14 Heating and cooking equipment**

2.1.14.1 Every heating or cooking appliance is to be controlled as a complete unit by a multi-pole linked switch mounted in the vicinity of the appliance.

2.1.14.2 In the case of small heaters, for individual cabins or similar small dry accommodation spaces where the floor coverings, bulkheads and ceiling linings are of insulating materials, a single pole switch is acceptable.

2.1.14.3 Heating arrangements of the exposed element type are not to be used in any location.

**2.1.15 Temporary external supply/shore connection**

2.1.15.1 Where arrangements are provided for the supply of electric power from a source on shore or elsewhere, a connection box is to be installed in an easily accessible location in a manner suitable for the convenient reception of flexible cables from the external source. This box should contain a circuit-breaker or isolating switch and fuses and terminals of ample size and suitable shape to facilitate a satisfactory connection. The mechanical stress of the portable cable is to be conveyed directly to the metallic framework and not to electrical connectors. Suitable cables, permanently fixed, are to be provided, connecting the circuit breaker/isolating switch in the connection box to a linked switch and/or circuit breaker at the main switchboard.

2.1.15.2 For alternating current systems an earthed terminal is to be provided for the reception of three-phase external supplies with earthed neutrals.

2.1.15.3 The external connection is to be provided with an indicator at the main switchboard in order to show when the cable is energized.

2.1.15.4 Means are to be provided for checking the polarity (for direct current) or the phase sequence (for three-phase alternating current) of the incoming supply. This device should be connected between the incoming connectors and the interrupting device in the connection box.

2.1.15.5 A notice is to be provided at the connection box giving complete information on the system of supply and the normal voltage (and frequency for alternating current) of the ship's installed system. Full details of the procedure for effecting the connection are to be given on this notice.

2.1.15.6 Alternate arrangements for providing a temporary external supply will be specially considered.

**2.2 Protection**

**2.2.1 General**

2.2.1.1 Installations are to be protected against accidental over- currents including short circuits. The choice, location and characteristics of the protective device are to provide complete and co-ordinated protection to ensure:-

**क)** Elimination of the fault to reduce damage to the system and hazard of fire.

**ख)** Continuity of service so as to maintain, through the discriminative action of the protective devices, the supply to circuits not directly affected by the fault.

**2.2.2 Protection against overload**

2.2.2.1 Protection against overloads may be provided by circuit-breakers, automatic switches or fuses. The tripping characteristics of these devices are to be appropriate to the system. Fuses rated above 320 amperes are not to be used for protection against overload, but may be used for short- circuit protection.

**2.2.3 Protection against short-circuit**

2.2.3.1 Protection against short-circuit currents is to be provided by circuit-breakers or fuses.

2.2.3.2 The breaking capacity of every protective device is to be not less than the maximum value of the short-circuit current which can flow at the point of installation at the instant of contact separation.

2.2.3.3 The making capacity of every circuit-breaker or switch intended to be capable of being closed, if necessary, on short circuit, is to be not less than the maximum value of the short-circuit current at the point of installation. On alternating current this maximum value corresponds to the peak value allowing for maximum asymmetry.

2.2.3.4 Every protective device or contactor not intended for short circuit interruption is to be adequate for the maximum short-circuit current which can occur at the point of installation having regard to the time required for the short circuit to be removed.

2.2.3.5 In the absence of precise data of rotating machines the following short-circuit currents at the machine terminals are to be assumed. The short circuit current is to be the sum of short circuit currents of generators and that of motors;

**क)** Direct current systems

Ten times full load current for generators normally connected (including spare),

Six times full load current for motors simultaneously in service;

**ख)** Alternating current systems.

Ten times full load current for generators normally connected (including spare) - symmetrical RMS,

Three times full load current for motors simultaneously in service.

**2.2.4 Combined circuit-breakers and fuses**

2.2.4.1 The use of a circuit-breaker of breaking capacity less than the prospective short-circuit current at the point of installation is permitted, provided that it is preceded on the generator side by fuses, or by a circuit-breaker having at least the necessary breaking capacity. The generator breakers are not to be used for this purpose.

2.2.4.2 Fused circuit-breakers with fuses connected to the load side may be used where operation of the circuit-breaker and fuses is co-ordinated.

2.2.4.3 The characteristics of the arrangement are to be such that:-

क) When the short-circuit current is broken, the circuit-breaker on the load side is not to be damaged and is to be capable of further service,

ख) When the circuit-breaker is closed on the short-circuit current, the remainder of the installation is not to be damaged. However, it is admissible that the circuit-breaker on the load side may require servicing after the fault has been cleared.

**2.2.5 Protection of circuits**

2.2.5.1 Short circuit protection is to be provided in each live pole of a direct current system and in each phase of an alternating current system.

2.2.5.2 Protection against overloads is to be provided as follows:-

क) Two-wire direct current or single-phase alternating current system - at least one line or phase,

ख) Insulated three-phase alternating current system - at least two phases,

ग) Earthed three-phase alternating current system - all three phases.

2.2.5.3 No fuse, non-linked switch or non-linked circuit-breaker is to be inserted in an earthed conductor. Any switch or circuit-breaker fitted is to operate simultaneously in the earthed conductor and the insulated conductors.

2.2.5.4 These requirements do not preclude the provision (for test purposes) of an isolating link to be used only when the other conductors are isolated.

**2.2.6 Protection of generators**

2.2.6.1 In addition to over-current protection, the provisions of 2.2.6.2 to 2.2.6.7 are to be adhered to as a minimum.

2.2.6.2 For generators not arranged to run in parallel a multi-pole circuit-breaker arranged to open simultaneously all insulated poles or in the case of generators rated at less than 50 [kW] a multi-pole linked switch with a fuse in each insulated pole on the generator side is to be provided. The fuse rating in such cases is to be maximum 125 per cent of the generator rated current.

2.2.6.3 For generators arranged to run in parallel a circuit-breaker arranged to open simultaneously all insulated poles is to be provided. This circuit-breaker is to be provided with:-

क) For direct current generators, instantaneous reverse-current protection operating at not more than 15 per cent rated current,

ख) For alternating current generators -

i) A reverse-power protection, with time delay selected and set within the limits of 2 per cent to 15 per cent of full load to a value fixed in accordance with characteristics of primemovers.

ii) A device for protection against the effects of parallel connection in opposite phase.

2.2.6.4 The reverse-current protection is to be adequate to deal with the reverse-current conditions emanating from the network, e.g. from winches. The reverse-power protection specified for alternating current generators may be replaced by other devices ensuring adequate protection of the prime movers.

2.2.6.5 Generator circuit-breakers are normally to be provided with under voltage release.

**2.2.7 Protection of feeder circuits**

2.2.7.1 Isolation and protection of each main distribution circuit is to be ensured by a multi-pole circuit-breaker or multi-pole switch and fuses. The provisions of 2.2.2, 2.2.3 and 2.2.5 are to be complied with. The protective devices are to allow excess current to pass during the normal accelerating period of motors. Where multi-pole switch and fuses are used, the fuses are generally to be installed between the busbars and the switch.

2.2.7.2 Circuits which supply motors fitted with overload protection may be provided with short-circuit protection only.

2.2.7.3 Motors of rating exceeding 0.5 [kW] are to be protected individually against overload and short-circuit. The short-circuit protection can be provided by the same protective device for the motor and its supply cable. The overload protection may be replaced by an overload alarm, if desired by the Owner.

**2.2.8 Protection of power transformers**

2.2.8.1 The primary circuits of power transformers are to be protected against short-circuit by circuit-breakers or fuses. The rating of fuses or the setting for overcurrent releases of circuit breakers is not to exceed 125 per cent of rated primary current.

2.2.8.2 When transformers are arranged to operate in parallel, means are to be provided for isolation of the secondary circuits. Switches and circuit-breakers are to be capable of withstanding surge currents.

**2.2.9 Protection of lighting circuits**

2.2.9.1 Lighting circuits are to be provided with overload and short- circuit protection.

**2.2.10 Protection of meters, pilot lamps, capacitors and control circuits**

2.2.10.1 Protection is to be provided for voltmeters, voltage coils of measuring instruments, earth indicating devices and pilot lamps, together with their connecting leads by means of protective devices fitted to each insulated pole or phase.

2.2.10.2 A pilot lamp installed as an integral part of another item of equipment need not be individually

protected, provided it is fitted in the same enclosure. Where a fault in a pilot lamp would jeopardise the supply to essential equipment such lamps are to be individually protected.

**2.2.11 Protection of batteries**

2.2.11.1 Accumulator batteries other than engine starting batteries are to be protected against short circuit by devices, in each insulated pole, placed at a position adjacent to the battery compartment.

**2.2.12 Protection of communication circuits**

2.2.12.1 Communication circuits other than those supplied from primary batteries are to be protected against overload and short-circuit.

**2.3 Renewable sources of electrical power**

2.3.1 General requirements for solar power systems

2.3.1.1 Solar power may be used as an additional source for charging battery systems. Suitable changeover arrangements are to be provided to ensure charging of the batteries when the output from photovoltaic (PV) panels is not sufficient to charge the batteries.

2.3.1.2 The components of solar power systems are to be suitably sized for charging the connected batteries.

2.3.1.3 The PV panels and associated power system components are to be suitable for marine use.

2.3.1.4 Following are to be considered while designing and sizing the solar power system:

- environmental conditions
- geographical conditions
- solar radiation
- rated voltage and current
- photovoltaic module maintenance requirements
- storage battery capacity

2.3.1.5 Adequate space and access is to be provided for operation, inspection and maintenance. Cables are to be secured by cable ties, hangers or similar fittings and terminated appropriately.

2.3.1.6 All live parts of the solar power system are to be insulated and protected by barrier/ enclosure, where required by the Rules.

2.3.1.7 Manufacturer's instructions regarding maintenance and replacement of PV modules are to be available onboard.

2.3.1.8 Tests and trials are to be carried out to verify satisfactory operation of solar power systems.

2.3.1.9 PV modules are to comply with recognised standards such as:

(a) IEC 61215-1:2021 *Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1: Test requirements*

(b) IEC 61215-2:2021 *Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1: Test procedures*

(c) IEC 61701:2020 - *Photovoltaic (PV) modules - Salt mist corrosion testing*

(d) IEC 61730-1:2016 – *Photovoltaic (PV) module safety qualification, Requirements for construction*

(e) IEC 62716:2016 – *Photovoltaic (PV) modules - Ammonia corrosion testing*

(for modules installed on-board ammonia carriers)

## Section 3

## Cables

**3.1 General**

3.1.1 Cables are to be in accordance with an acceptable National or International Standard, due regard being given to the ambient conditions stated in 1.5.

**3.2 Insulating materials**

3.2.1 Permitted insulating materials with maximum rated conductor temperatures are given in Table 3.2.1.

3.2.2 The rated operating temperature of the insulating material is to be at least 10°C higher than the maximum ambient temperature liable to be produced in the space where the cable is installed.

3.2.3 Where a rubber or rubber like material with maximum conductor temperature greater than 60°C is used, it is to be readily identifiable.

**3.3 Sheaths and protective coverings**

3.3.1 Cables are to be protected by one or more of the following, and the material of the sheath or protective covering is to be compatible with the material of the insulation:-

(a) Sheath

Lead-alloy

Copper

Non-metallic

(b) Protective covering

Steel-wire armour

Steel-tape armour

Metal-braid armour (basket weave)

Fibrous braid

3.3.2 Unsheathed cables, e.g. rubber insulated taped and braided or equivalent, may be used only if installed in conduit.

3.3.3 Non-metallic sheath : Polychloroprene compound, polyvinyl chloride compound and chlorosulphonated polyethylene may be used for impervious sheaths. Other compounds will be given due consideration.

**Table 3.2.1 : Insulating materials**

| Insulating materials | Max. rated conductor temp.°C |
|---|---|
| **Elastomeric Compounds** | |
| Natural or synthetic rubber (general purpose) | 60 |
| **Rubber** | |
| Butyl rubber | 80 |
| Ethylene propylene rubber | 85 |
| Silicone rubber | 95 |
| **Thermoplastic Compounds** | |
| Polyvinyl chloride (general purpose) | 60 |
| Polyvinyl chloride (heat resisting quality) | 75 |
| **Other Materials** | |
| Minerals | 95 |

Notes:

1. Silicone rubber and mineral insulation may be used for higher temperatures (upto 150°C for silicone rubber and upto 250°C for mineral insulation) when installed where they are not liable to be touched by personnel. Proposals for such installations will be specially considered.
2. The temperature of the conductor is the combination of ambient temperature and temperature rise due to load.
3. Other insulating materials will be considered.

3.3.4 Fibrous braid : Textile braid is to be of cotton, hemp, asbestos, glass or other equivalent fiber, and is to be of strength suitable for the size of the cable. It is to be effectively impregnated with a compound which is resistant to moisture and which is flame retarding.

**3.3.5 Cables fitted in the following locations:-**

– Decks exposed to weather;

– Bathrooms;

– Cargo holds;

– Machinery spaces;

or any other location where water condensation or harmful vapour (e.g. oil vapour) may be present are to have an impervious sheath. In permanently wet situations, metallic sheaths are to be used for cables with hygroscopic insulation.

3.3.6 All cables are to be of flame-retardant type or fire-resisting type, except that non flame-retardant cables may be accepted for final circuits only where cables are installed in metallic conduits having internal diameter not exceeding 25 [mm] and provided the conduits are electrically and mechanically continuous.

**3.4 Voltage rating**

3.4.1 The rated voltage of any cable is to be not lower than the nominal voltage of the circuit for which it is used.

3.4.2 The voltage drop from the main switchboard bus bars to any point in the installation when the cables are carrying maximum current under normal conditions of service is not to exceed 6 per cent of the nominal voltage.

**3.5 Current rating**

3.5.1 The highest continuous load carried by a cable is not to exceed its current rating. The diversity factor of the individual loads and the duration of the maximum demand may be allowed for in estimating the maximum continuous load and is to be shown on the plans submitted for approval.

3.5.2 In assessing the current rating of lighting circuits, every lampholder is to be assessed at the maximum load likely to be connected to it, with a minimum of 60 W, unless the fitting is so connected as to take only a lamp rated at less than 60 W.

3.5.3 Cables supplying winches, cranes, windlasses and capstans are to be suitably rated for their duty. Unless the duty is such as to require a longer time rating, cables for winch or crane motors may be half hour rated on the basis of the half hour [kW] rating of the motors. Cables for windlass and capstan motors are to be not less than one hour rated on the basis of the one hour [kW] rating of the motor. In all cases the rating is to be subject to the voltage drop being within the specified limits.

3.5.4 The current ratings given in Tables 3.5.1 to 3.5.5 are based on the maximum operating conductor temperatures, given in Table 3.2.1. Alternatively current rating in accordance with an acceptable National or International Standard may be applied. See 3.1.1.

**Table 3.5.1 : General purpose rubber and PVC insulation current rating**

**(Based on ambient temp. 45°C)**

| **Nominal cross-section** | **Single core** | **2 core** | **3 or 4 core** |
|---|---|---|---|
| **[mm²]** | **amperes** | **amperes** | **amperes** |
| 1 | 8 | 7 | 6 |
| 1.5 | 12 | 10 | 8 |
| 2.5 | 17 | 14 | 12 |
| 4 | 22 | 19 | 15 |
| 6 | 29 | 25 | 20 |
| 10 | 40 | 34 | 28 |
| 16 | 54 | 46 | 38 |
| 25 | 71 | 60 | 50 |
| 35 | 87 | 74 | 61 |
| 50 | 105 | 89 | 74 |
| 70 | 135 | 115 | 95 |
| 95 | 165 | 140 | 116 |
| 120 | 190 | 162 | 133 |
| 150 | 220 | 187 | 154 |
| 185 | 250 | 213 | 175 |
| 240 | 290 | 247 | 203 |
| 300 | 335 | 285 | 235 |
| | d.c. a.c. | d.c. a.c. | d.c. a.c. |
| 400 | 390 380 | 332 323 | 273 266 |
| 500 | 450 430 | 383 365 | 315 301 |
| 630 | 520 470 | 442 400 | 364 329 |

### 3.6 Correction factors for current rating

3.6.1 **Bunching of cables** : Where more than six cables belonging to the same circuit are bunched together a correction factor of 0.85 is to be applied.

**Table 3.5.2 : Heat resisting PVC insulation current rating**

**(Based on ambient temp. 45°C)**

| **Nominal cross-section** | **Single core** | **2 core** | **3 or 4 core** |
|---|---|---|---|
| **[mm²]** | **amperes** | **amperes** | **amperes** |
| 1 | 13 | 11 | 9 |
| 1.5 | 17 | 14 | 12 |
| 2.5 | 24 | 20 | 17 |
| 4 | 32 | 27 | 22 |
| 6 | 41 | 35 | 29 |
| 10 | 57 | 48 | 40 |
| 16 | 76 | 65 | 53 |
| 25 | 100 | 85 | 70 |
| 35 | 125 | 106 | 88 |
| 50 | 150 | 128 | 105 |
| 70 | 190 | 162 | 133 |
| 95 | 230 | 196 | 161 |
| 120 | 270 | 230 | 189 |
| 150 | 310 | 264 | 215 |
| 185 | 350 | 298 | 245 |
| 240 | 415 | 353 | 291 |
| 300 | 475 | 404 | 333 |
| | d.c. a.c. | d.c. a.c. | d.c. a.c. |
| 400 | 570 560 | 485 475 | 400 390 |
| 500 | 650 620 | 550 530 | 455 435 |
| 630 | 740 670 | 630 570 | 520 470 |

**Table 3.5.3 : Butyl insulation current rating**

**(Based on ambient temp. 45°C)**

| **Nominal cross-section** | **Single core** | **2 core** | **3 or 4 core** |
|---|---|---|---|
| **[mm²]** | **amperes** | **amperes** | **amperes** |
| 1 | 15 | 13 | 11 |
| 1.5 | 19 | 16 | 13 |
| 2.5 | 26 | 22 | 18 |
| 4 | 35 | 30 | 25 |

| | | | |
|---|---|---|---|
| 6 | 45 | 38 | 32 |
| 10 | 63 | 54 | 44 |
| 16 | 84 | 71 | 59 |
| 25 | 110 | 94 | 77 |
| 35 | 140 | 119 | 98 |
| 50 | 165 | 140 | 116 |
| 70 | 215 | 183 | 151 |
| 95 | 260 | 221 | 182 |
| 120 | 300 | 255 | 210 |
| 150 | 340 | 289 | 238 |
| 185 | 390 | 332 | 273 |
| 240 | 460 | 391 | 322 |
| 300 | 530 | 450 | 371 |
| | d.c. a.c. | d.c. a.c. | d.c. a.c. |
| 400 | 610 590 | 519 502 | 427 413 |
| 500 | 690 640 | 587 544 | 483 448 |
| 630 | 790 690 | 672 587 | 553 483 |

**Table 3.5.4 : Ethylene propylene rubber, cross-linked polyethylene insulation current rating**

**(Based on ambient temp. 45°C)**

| Nominal cross-section | Single core | 2 core | 3 or 4 core |
|---|---|---|---|
| [mm$^2$] | amperes | Amperes | amperes |
| 1 | 16 | 14 | 11 |
| 1.5 | 20 | 17 | 14 |
| 2.5 | 28 | 24 | 20 |
| 4 | 38 | 32 | 27 |
| 6 | 48 | 41 | 34 |
| 10 | 67 | 57 | 47 |
| 16 | 90 | 77 | 63 |
| 25 | 120 | 102 | 84 |
| 35 | 145 | 123 | 102 |
| 50 | 180 | 153 | 126 |
| 70 | 225 | 191 | 158 |
| 95 | 275 | 234 | 193 |
| 120 | 320 | 272 | 224 |
| 150 | 365 | 310 | 256 |
| 185 | 415 | 353 | 291 |
| 240 | 490 | 417 | 343 |
| 300 | 560 | 476 | 392 |
| | d.c. a.c. | d.c. a.c. | d.c. a.c. |
| 400 | 650 630 | 553 536 | 445 441 |
| 500 | 740 680 | 629 578 | 518 476 |
| 630 | 840 740 | 714 629 | 588 516 |

**Table 3.5.5 : Silicon rubber, mineral insulation current rating**

**(Based on ambient temp. 45°C)**

| Nominal cross-section | Single core | 2 core | 3 or 4 core |
|---|---|---|---|
| [mm$^2$] | amperes | Amperes | amperes |
| 1 | 20 | 17 | 14 |
| 1.5 | 24 | 20 | 17 |
| 2.5 | 32 | 27 | 22 |
| 4 | 42 | 36 | 29 |
| 6 | 55 | 47 | 39 |
| 10 | 75 | 64 | 53 |
| 16 | 100 | 85 | 70 |
| 25 | 135 | 115 | 95 |
| 35 | 165 | 140 | 116 |

| | | | |
|---|---|---|---|
| 50 | 200 | 175 | 140 |
| 70 | 255 | 217 | 179 |
| 95 | 310 | 264 | 217 |
| 120 | 360 | 306 | 252 |
| 150 | 410 | 349 | 287 |
| 185 | 470 | 400 | 329 |
| 240 | 570 | 485 | 400 |
| 300 | 660 | 560 | 460 |

**Table 3.6.1 : Correction factors for temperature**

| Insulation | Correction factor for ambient temperature in °C | | | | | | |
|---|---|---|---|---|---|---|---|
| | 25 | 30 | 35 | 40 | 45 | 50 | 55 |
| Rubber or PVC (general purpose) | 1.53 | 1.41 | 1.29 | 1.15 | 1.00 | 0.82 | 0.58 |
| PVC (heat-resisting quality) | 1.29 | 1.22 | 1.15 | 1.08 | 1.00 | 0.91 | 0.82 |
| Butyl rubber | 1.25 | 1.2 | 1.13 | 1.07 | 1.pp | 0.93 | 0.85 |
| Ethylene propylene rubber, cross-linked polyethylene | 1.22 | 1.17 | 1.12 | 1.06 | 1.00 | 0.94 | 0.87 |
| Mineral, silicone rubber | - | - | - | 1.05 | 1.00 | 0.95 | 0.89 |

Notes:

1 For cables in refrigerated chambers and holds and for vessels restricted to service in non-tropical waters, correction factors for 35°C may be acceptable.

2 Correction factors for intermediate values of the ambient temperature can be ascertained by interpolation.

**Table 3.6.2 : Correction factors for intermittent rating**

| Correction factor | Half-hour rating | | One-hour rating | |
|---|---|---|---|---|
| | With metallic sheath [$mm^2$] | Without metallic sheath [$mm^2$] | With metallic sheath [$mm^2$] | Without metallic sheath [$mm^2$] |
| 1.00 | Upto 20 | Upto 75 | Upto 67 | Upto 230 |
| 1.10 | 21 - 40 | 76 - 125 | 68 - 170 | 231 - 400 |
| 1.15 | 41 - 65 | 126 - 180 | 171 - 290 | 401 - 600 |
| 1.20 | 66 - 95 | 181 - 250 | 291 - 430 | - |
| 1.25 | 96 - 120 | 251 - 320 | 431 - 600 | - |
| 1.30 | 131 - 170 | 321 - 400 | - | - |
| 1.35 | 171 - 220 | 401 - 500 | - | - |
| 1.40 | 221 - 270 | - | - | - |

3.6.2 **Ambient temperature** : The current ratings in Table 3.5.1 to 3.5.5 are based on an ambient temperature of 45°C. For other values of ambient temperature the correction factors shown in Table 3.6.1, are to be applied.

3.6.3 **Intermittent service** : Where the load is intermittent, the correction factors in Table 3.6.2 may be applied for half hour and one hour ratings. In no case is a shorter rating than one half hour rating to be used, whatever the degree of intermittency.

**3.7 Testing**

3.7.1 Tests in accordance with an acceptable National or International Standard are to be made at the manufacturer's works prior to dispatch.

**3.8 Connections between entrained ships**

3.8.1 Cables are to be suitable for use in the connections between entrained ships i.e., are to be flexible, robust and of commensurate cross-section area.

3.8.2 The connection is to include provisions for the continuity of out-of-balance or earth-fault current return. The connecting device is to include provisions to ensure that this circuit is closed before, and opened after, the live circuits.

3.8.3 Terminal plugs and sockets, if used, are to be so arranged that any exposed pins cannot be energized.

3.8.4 Where hull-return systems are used, hull polarity is to be compatible.

**3.9 Installation of cables**

3.9.1 Cable runs are to be, as far as practicable, straight and accessible and as high as possible above bilges.

3.9.2 Cables having insulating materials with different maximum-rated conductor temper-atures are not to be bunched together, or, where this is not practicable, the cables are to be operated so that no cable reaches temperature higher than that permitted for the lowest temperature-rated cable in the group.

3.9.3 Cables having a protective covering which may damage the covering of other cables are not to be bunched with those other cables.

3.9.4 The minimum internal radius of bends of installed cables is to be generally in accordance with following :

| | |
|---|---|
| 4d | for cables without braiding, armouring or other metal sheath and with an overall diameter not exceeding 25 [mm] |
| 6d | for all other cables |
| (d = overall diameter of cable) | |

3.9.5 Cables, are to be effectively supported and secured in a manner that prevents damage to their coverings.

3.9.6 Supports and accessories are to be robust and are to be of corrosion-resistant material or suitably corrosion inhibited before erection.

3.9.7 The distance between supports, for horizontal as well as vertical runs of cables, is to be chosen according to the type/size of cable, but generally in accordance with Table 3.9.1.

**3.10 Mechanical protection of cables**

3.10.1 Cables exposed to risk of mechanical damage are to be protected by metal channels or casing or enclosed in steel conduit unless the protective covering (e.g. armour or sheath) is adequate to withstand the possible damage.

**Table 3.9.1 : Distance between supports**

| External diameter of cable | | Non-armoured cables | Armoured cables |
|---|---|---|---|
| Excee-ding | Not excee-ding | | |
| [mm] | [mm] | [mm] | [mm] |
| - | 8 | 200 | 250 |
| 8 | 13 | 250 | 300 |
| 13 | 20 | 300 | 350 |
| 20 | 30 | 350 | 400 |

3.10.2 Cables, in spaces where there is exceptional risk of mechanical damage (e.g. on weather decks, in cargo hold areas and inside the cargo holds) and also below the floor in engine room, are to be suitably protected, even if armoured, unless the steel structure affords adequate protection.

3.10.3 Metal casings for mechanical protection of cables are to be efficiently protected against corrosion.

**3.11 Earthing of metal coverings**

3.11.1 Metal coverings of cables are to be effectively earthed at both ends of the cable, except in final sub-circuits, where earthing at the supply end only will be considered adequate. This does not necessarily apply to instrumentation cables where single point earthing may be desirable for technical reasons.

3.11.2 The electrical continuity of all metal coverings of cables throughout the length of the cable, particularly at joints and tappings, is to be ensured.

3.11.3 The lead sheath of lead-sheathed cables is not to be used as the sole means of earthing the non-current carrying parts of items of equipment.

**3.12 Penetration of bulkheads and decks by cables**

3.12.1 Penetration of watertight bulkheads or decks is to be carried out with either individual watertight glands or with packed watertight boxes carrying several cables. In either case, the watertight integrity and strength of the bulkheads and decks are to be maintained. Where cables with polyvinyl chloride insulation are being installed, particular care is to be taken to avoid damage to the sheathing during the fitting of watertight bulkhead glands.

3.12.2 Where cables pass through non-watertight bulkheads or structural steel, the holes are to be bushed, in order to protect the cables, with lead or other approved material which will prevent damage to the cables by abrasion. If the steel is 6 [mm] thick, adequately rounded edges may be accepted as the equivalent of bushing.

3.12.3 Cables passing through decks are to be protected by deck tubes or ducts.

3.12.4 Materials used for glands and bushings are to be such that there is no risk of corrosion.

3.12.5 Where rectangular holes are cut in bulkheads or structural steel the corners are to be adequately rounded.

**3.13 Installation of cables in pipes and conduits**

3.13.1 Installation of cables in pipes and conduits is to be carried out in such a manner that there is no damage to the cable covering.

3.13.2 Metal conduit systems are to be earthed and are to be mechanically and electrically continuous across joints. Individual short lengths of conduit need not be earthed.

3.13.3 The internal radius of bend of pipes and conduit is to be not less than that laid down for cables, provided that for pipes exceeding 64 [mm] diameter the internal radius of bend is not less than twice the diameter of the pipe.

3.13.4 The drawing-in factor (ratio of the sum of the cross-sectional areas of the cables, based on their external diameter, to the internal cross-section area of the pipe) is not to exceed 0.4.

3.13.5 Expansion joints are to be provided where necessary.

3.13.6 Cable pipes and conduits are to be adequately and effectively protected against corrosion. Where necessary, openings are to be provided at the highest and lowest points to permit air circulation and to prevent accumulation of water.

3.13.7 Where cables are laid in trunks, the trunks are to be so constructed as not to afford passage for fire from one deck or compartment to another.

3.13.8 Non-metallic ducting or conduit is to be of flame-retardant material. PVC conduit is not to be used in refrigerated spaces or on open decks, unless specially approved.

**3.14 Cables for alternating current**

3.14.1 Generally, multi-core cables are to be used in A.C. installations. Where it is necessary to use single-core cables for alternating current circuits rated in excess of 20 amperes the requirements of 3.14.2 to 3.14.8 are to be complied with.

3.14.2 Cables are to be either non-armoured or armoured with non- magnetic material.

3.14.3 If installed in pipe or conduit, cables belonging to the same circuit are to be installed in the same conduit, unless the conduit or pipe is of non-magnetic material.

3.14.4 Cable clips are to include cables of all phases of a circuit unless the clips are of non-magnetic material.

3.14.5 When installing two, three or four single-core cables forming respectively single-phase circuits, three-phase circuits or three-phase and neutral circuits, the cables are to be in contact with one another, as far as possible. In any case, the distance between the external covering of two adjacent cables is not to be greater than one diameter.

3.14.6 In the case of circuits using two or more parallel connected cables per phase, all cables are to have the same length and cross sectional area.

3.14.7 Where single core cables of rating exceeding 50 amperes are used, magnetic material is not to be placed between single-core cables of a group. If these cables pass through steel plates, all cables of the same circuit are to pass through the plate or gland so constructed that there is no magnetic material between the cables, and suitable clearance is provided between the cable core and magnetic material. This clearance, wherever practicable, is not to be less than 75 [mm] when the current exceeds 300 amperes. For currents between 50 amperes and 300 amperes the clearance may be proportionately reduced.

3.14.8 If single-core cables of current rating greater than 250 amperes are run along a steel bulkhead, wherever practicable the cables should be spaced away from the steel.

**3.15 Cable ends**

3.15.1 The ends of all conductors of cross-sectional area greater than 4 [$mm^2$] are to be fitted with soldering sockets, compression type sockets or mechanical clamps. Corrosive fluxes are not to be used.

3.15.2 Cables having hygroscopic insulation (e.g. mineral insulated) are to have their ends sealed against ingress of moisture.

3.15.3 Cables with a supplementary insulating belt beneath the protective sheath are to have additional insulation at those points where the insulation of each core makes or may make contact with earthed metal.

**3.16 Joints and branch circuits in cable systems**

3.16.1 Cable runs are normally not to include joints. However, if a joint is necessary it is to be carried so that all conductors are adequately secured, insulated and protected from atmospheric action. Terminals and busbars are to be of dimensions adequate for the cable rating.

## Section 4

## Switchboards

**4.1 General**

4.1.1 Switchboards, section boards and distribution boards are to be constructed of, or enclosed with non-flammable, non-hydroscopic material and are to be so installed that live parts are sufficiently guarded and adequate space is provided for maintenance. Also they are to be protected where necessary in way of pipes etc.

4.1.2 All measuring instruments and all apparatus controlling circuits are to be clearly and indelibly labeled for identification purposes. An indelible label is to be permanently secured adjacent to every fuse and every circuit breaker and marked with particulars of the full load current of the generator, motor or cable which the fuse or circuit breaker protects. Where inverse time limit and/or reverse current devices are provided in connection with a circuit breaker, the appropriate settings of these devices are to be stated on the label. Name plates are to be of flame retardant material.

**4.2 Instruments**

4.2.1 Sufficient instrumentation is to be provided for measuring voltage, current, frequency and, for alternating current generators above 50 [kW].

4.2.2 Where alternating current generators are required to operate in parallel, synchronising arrangements are to be fitted.

**4.3 Instrument transformers**

4.3.1 The secondary windings of instrument transformers are to be earthed.

**4.4 Switchgear**

4.4.1 Circuit breakers and switches are to be of the air break type and are to be constructed in accordance with an acceptable National or International Standard.

4.4.2 Report of tests to establish the capacity of circuit-breakers are to be submitted for consideration when required.

4.4.3 Overcurrent releases are to be calibrated in amperes and settings marked on the circuit-breaker.

**4.5 Fuses**

4.5.1 Fuses are to comply with an acceptable National or International Standard.

4.5.2 Fuse links and fuse bases are to be marked with particulars of rated current and rated voltage. Each fuse position is to be permanently and indelibly labeled with the current carrying capacity of the circuit protected by it and with the appropriate approved size of fuse or replaceable element.

**4.6 Testing**

4.6.1 Before installation, switchboards complete or in sections with all components are to pass the following tests at the manufacturer's works and a certificate furnished. A high voltage test is to be carried out in all switching and control apparatus for systems greater than 60V with a test voltage of 1000V plus twice the rated voltage with a minimum of 2000V at any frequency between 25 and 100 Hz for one minute applied between (a) all current-carrying parts connected together and earth and (b) between current carrying parts of opposite polarity or phases.

4.6.2 For systems of 60V or less the test shall be at 500V for one minute.

4.6.3 Instruments and ancillary apparatus may be disconnected during the high voltage test.

4.6.4 Immediately after the high voltage test, the insulation resistance between (a) all current-carrying parts connected together and earth and (b) between current carrying parts of opposite polarity or phase, shall not be less than 1 Megohm when tested with a direct current voltage of at least 500V.

4.6.5 Functional tests. The correct functions of the installation components in line with the connections intended to be made have to be checked as far as possible.

## Section 5

## Control Gear

**5.1 General**

5.1.1 Control gear is to comply with an acceptable National or International Standard, amended where necessary for ambient temperature.

5.1.2 Control gear, including isolating and reversing switches, is to be so arranged that shunt field circuits are not disconnected without adequate discharging path being provided.

**5.2 Testing**

5.2.1 Control gear and resistors are to be tested by the manufacturers with a high voltage applied between the earthed frame and all live parts and a

certificate furnished by them to this effect. For operating voltages above 55 V, the test voltage is to be 1000 V plus twice the rated voltage with a minimum of 2000 V. The voltage is to be alternating at any frequency between

25 and 100 Hz and is to be maintained for one minute without failure.

5.2.2 Control gear and resistors operating at 55 V or below are to be tested to 500 V for one minute.

5.2.3 Immediately after the high voltage test, the insulation resistance between (a) all current-carrying parts connected together and earth, and (b) between current-carrying parts of opposite polarity or phase, is not to be less than 1 megaohm when tested with a direct current voltage of at least 500 V.

5.2.4 Instruments and ancillary apparatus may be disconnected during the high voltage test.

5.2.5 **Functional Test** : The correct functions of the installation components in line with the connections intended to be made, have to be checked as far as possible.

## Section 6

## Rotating Machines Construction and Testing

### 6.1 General

6.1.1 Rotating machines are to be constructed in accordance with an acceptable National or International Standard, due regard being given to the ambient conditions stated in 1.5.

### 6.2 Rating

6.2.1 Ship's service generators including their exciters, and continuously rated motors are to be suitable for continuous duty at their full rated output at maximum cooling air or water temperature for an unlimited period, without the limits of temperature rise in 6.3 being exceeded. Other generators and motors are to be rated in accordance with the duty which they are to perform, and when tested under rated load conditions the temperature rise is not to exceed the values in 6.3. Alternatively limits of temperature rise in accordance with an acceptable National or International Standard may be applied.

### 6.3 Temperature rise

6.3.1 The limits of temperature rise specified in Table 6.3.1 are based on a cooling air temperature of 45°C and a cooling water temperature of 30°C.

6.3.2 If the temperature of the cooling medium is known to exceed the value given in 6.3.1, the permissible temperature rise is to be reduced by an amount equal to the excess temperature of the cooling medium.

6.3.3 If the temperature of the cooling medium is known to be permanently less than the value given in 6.3.1, the permissible temperature rise may be increased by an amount equal to the difference between the declared temperature and that given in 6.3.1 upto a maximum of 15°C.

**Table 6.3.1 : Limits of temperature rise in °C**

| Item | Part of machines | Method of measurement of temperature | Temperature rise in air-cooled machines °C Insulation Class | | |
|---|---|---|---|---|---|
| | | | A | E | B |
| 1 (a) | a.c. windings | R | 50 | 65 | 70 |
| | | T | 40 | 55 | 60 |
| (b) | Field windings of a.c. and d.c. machines having d.c. excitation other than those in Items 2 and 3 | R | 50 | 65 | 70 |
| | | T | 40 | 55 | 60 |
| (c) | Windings of armatures having commutators | R | 50 | 65 | 70 |
| | | T | 40 | 55 | 60 |
| 2 | Field windings of turbine-type machines having d.c. excitation | R | - | - | 80 |
| 3 (a) | Low-resistance field windings of more than one layer and compensating windings | T,R | 50 | 65 | 70 |
| (b) | Single-layer windings with exposed bare surfaces | T,R | 55 | 70 | 80 |

| | | | | | |
|---|---|---|---|---|---|
| 4 | Permanently short-circuited insulated windings | T | 50 | 65 | 70 |
| 5 | Permanently short-circuited windings uninsulated | T | The temperature rise of these parts shall in no case reach such a value that there is a risk of injury to any insulating or other material on adjacent parts | | |
| 6 | Iron core and other parts not in contact with windings | - | The temperature rise of these parts shall in no case reach such a value that there is a risk of injury to any insulating or other material on adjacent parts | | |
| 7 | Iron core and other parts in contact with windings | T | 50 | 65 | 70 |
| 8 | Commutators and slip-rings open or enclosed | T | 50 | 60 | 70 |

Notes:

1 T = Thermometer method

R = Resistance method

2 When Class F or Class H insulation is employed, the permitted temperature rises are respectively 20°C and 40°C higher than the values given for Class B insulation.

3 Classes of insulation are to be in accordance with IEC Publication 85 (1957) - "Recommendations for the Classification of Material for the Insulation of Electrical Machinery and Apparatus in relation to their Thermal Stability in Service".

**6.4 Direct current service generators**

6.4.1 Shunt wound direct current generators are to be provided with automatic voltage regulators.

6.4.2 Direct current generators used for charging batteries without series-regulating resistors are to be either:-

(a) Shunt wound, or

(b) Compound wound with switches arranged so that the series winding can be switched out of service.

6.4.3 If terminal voltage is required to be manually adjusted to ensure satisfactory operation of generators, then, facilities are to be provided at the switchboard or at an appropriate and convenient control position to enable such adjustments to be made.

6.4.4 For each direct current generator, whilst being driven by its prime mover, at any temperature within the working range, the means provided is to be capable of adjusting the voltage at any load between no load and full load to within:-

**क)** 1.0 per cent of rated voltage for generators of rating less than 100 [kW],

**ख)** 0.5 per cent of rated voltage for generators of rating exceeding 100 [kW].

6.4.5 The inherent regulation of service generators is to be such that the following conditions are fulfilled:-

(a) For shunt or stabilised shunt wound generators when the voltage has been set at full load, the steady voltage at no load is not to exceed 115 per cent of the full load value, and the voltage obtained at any intermediate value of load is not to exceed the no-load value.

(b) For compound wound generators with the generator at full load operating temperature, and starting at 20 per cent load with voltage within 1 per cent of rated voltage, then at full load the voltage is to be within 2.5 per cent of rated voltage. The average of the ascending and descending load/voltage curves between 20 per cent load and full load is not to vary more than 4 per cent from rated voltage.

6.4.6 Generators are to be capable of delivering continuously the full load current and normal rated voltage at the terminals when running at full load engine speed at all ambient temperatures up to the specified maximum.

6.4.7 Generators required to run in parallel are to be stable from no load up to the total combined load of the group, and load sharing is to be satisfactory.

6.4.8 The series winding of each two-wire generator is to be connected to the negative terminal.

6.4.9 Equalizer connections are to have a cross-sectional area appropriate to the system but in no case less than 50 per cent of that of the negative connection from the generator to the switchboard.

**6.5 Alternating current service generators**

6.5.1 Each alternating current service generator, unless of the self regulating type, is to be provided with automatic means of voltage regulation.

6.5.2 The voltage regulation of any alternating current generator with its regulating equipment is to be such that at all loads from zero to full load the voltage at rated power factor is maintained under steady conditions within 2.5 per cent of rated voltage.

6.5.3 Alternating current generators required to run in parallel are to be stable from 20 per cent full load [kW] up to the total combined full load [kW] of the group, and load sharing is to be such that the load on any generator does not normally differ from its proportionate share of the total load by more than 15 per cent of the rated output [kW] of the largest machine or 25 per cent of the rated output [kW] of the individual machine, whichever is less.

6.5.4 When generators are operated in parallel, the KVA loads of the individual generating sets are not to differ from their proportionate share of the total KVA load by more than 5 per cent of the rated KVA output of the largest machine when operating at 0.8 power factor.

**6.6 Inspection and testing**

6.6.1 On machines for essential services tests are to be carried out in accordance with the relevant standard and a certificate furnished by the manufacturers.

6.6.2 Generators and motors of 100 [kW] or over intended for essential services are to be inspected by the Surveyors during manufacture and testing.

## Section 7

## Transformers - Construction and Testing

**7.1 General**

7.1.1 Transformers are to be in accordance with an acceptable National or International Standard, due regard being given to the ambient conditions stated in 1.5.

7.1.2 Transformers are to be of the dry, natural air cooled type. Proposals for the use of liquid cooled transformers will be subject to special consideration.

**7.2 Installation**

7.2.1 Transformers are to be placed in easily accessible well ventilated spaces free from any gaseous or acid fumes. They are to be clear of non-protected ignitable materials, and so arranged as to be protected against shocks and any damage resulting from water, oil, liquid fuel, steam etc.

**7.3 Construction**

7.3.1 Transformers are to be double wound except those for motor starting.

7.3.2 Each transformer is to be provided with a nameplate of corrosion-resistant metal giving information on make, type, serial number, insulation class and any other technical data necessary for the application of the transformer.

**7.4 Regulation**

7.4.1 The inherent regulation at 0.8 power factor is not to exceed 5 per cent.

7.4.2 Regulation of the complete system is to comply with 3.4.2.

**7.5 Short circuit**

7.5.1 All transformers are to be constructed to withstand, without damage, the thermal and mechanical effects of a short-circuit at the terminals of any winding for 2 seconds with rated primary voltage and frequency without damage.

**7.6 Tests**

7.6.1 Transformers for essential services are to be tested by the manufacturer in accordance with the relevant standard and test certificates supplied.

## Section 8

## Miscellaneous Equipment

**8.1 Accumulator batteries**

**8.1.1 Construction**

8.1.1.1 The cells of all batteries are to be so constructed and secured as to prevent spilling of the electrolyte due to the motion of the ship and to prevent emission of acid or alkaline spray.

8.1.1.2 All batteries are to be provided with durable labels of flame retardant material, giving information on the application for which the battery is intended, voltage and capacity.

**8.1.2 Location**

8.1.2.1 Alkaline batteries and lead acid batteries of the vented type are not to be installed in the same compartment.

8.1.2.2 Large batteries are to be installed in a space assigned to them only. A box on deck would meet this requirement if adequately ventilated and provided with means to prevent ingress of water.

8.1.2.3 Engine starting batteries are to be located as close as practicable to the engine(s) served. If such

batteries cannot be accommodated in the battery compartment, they are to be installed so that adequate ventilation is ensured.

**8.1.3 Installation**

8.1.3.1 Batteries should be so arranged that each cell or crate of cells is accessible from the top and at least one side.

8.1.3.2 Cells or crates are to be carried on non-absorbent insulating supports. Similar insulators are to be fitted to prevent any movement of cells arising from the motion of the vessel. Adequate space for circulation of air is to be ensured.

8.1.3.3 Where acid is used as the electrolyte a tray of acid resisting material is to be provided below the cells unless the deck below is similarly protected.

8.1.3.4 The interiors of all compartments including the shelves, are to be painted with corrosion resistant paint.

8.1.3.5 A permanent notice is to be fitted to all compartments prohibiting naked lights and smoking in the compartment.

8.1.3.6 Switches, fuses and other electrical equipment liable to cause an arc are not to be fitted in battery compartments.

**8.1.4 Ventilation**

8.1.4.1 Battery compartments, lockers and boxes are to be adequately ventilated by an independent ventilating system to avoid accumulation of flammable gases. Particular attention should be given to the fact that these gases are lighter than air and tend to accumulate at the top of the spaces.

8.1.4.2 Natural ventilation may be employed if ducts can be run directly from the top of the compartment to the open air with no part of the duct more than 45 degrees from the vertical. If natural ventilation is impracticable, mechanical ventilation is to be installed. Interior surfaces of ducts and fans are to be painted with corrosion-resistant paint. Fan motors are not to be located in the air stream.

8.1.4.3 Necessary precautions are to be taken to prevent sparking due to possible contact by the ventilation fan blades with fixed parts.

8.1.4.4 All openings through the battery compartment bulkheads or decks, other than ventilation openings, are to be effectively sealed to reduce the possibility of escape of gas from the battery compartment into the ship.

**8.2 Luminaries**

**8.2.1 General**

8.2.1.1 Lighting fittings installed in engine rooms or similar spaces where they are exposed to the risk of mechanical damage are to be provided with suitable grilled mechanical guards to protect their lamps and glass globes against such damage.

8.2.1.2 Precautions are to be taken so that a lamp for one voltage cannot be inserted in a lampholder for another voltage.

8.2.1.3 Incandescent lamps are to be in accordance with the following :-

| | |
|---|---|
| B22 | upto 250 V and 200 W |
| E27 | upto 250 V and 200 W |
| E40 | upto 210 V and 3000 W |

8.2.1.4 Lampholders are to be constructed of flame-retarding and non- hygroscopic material. All metal parts are to be of robust construction. Goliath lampholders (E40) are to be provided with means for locking the lamp in the holder. The temperature of cable connections is not to exceed the maximum conductor temperature permitted for the cable as given in Table 3.2.1.

8.2.1.5 The ratings of tubular fluorescent lamps are not to exceed 250 V and 80 W.

**8.3 Accessories - Construction and testing**

**8.3.1 Enclosures**

8.3.1.1 Enclosures are to be of metal or of flame-retardant insulating materials.

**8.3.2 Inspection and draw boxes**

8.3.2.1 If metal conduit systems are used, inspection and draw boxes are to be of metal and are to be in rigid electrical and mechanical connection with the conduits.

**8.3.3 Socket outlets and plugs**

8.3.3.1 Socket outlets and plugs are to be so constructed that they cannot be readily short-circuited whether the plug is in or out, and so that a pin of the plug cannot be made to earth either pole of the socket outlet.

8.3.3.2 All socket outlets of current rating 16 amperes or more are to be provided with a switch.

8.3.3.3 Where it is necessary to earth the non-current-carrying parts of portable or transportable equipment, an effective means of earthing is to be provided at the socket outlet.

8.3.3.4 In all wet situations socket outlets and plugs are to be effectively shielded against rain and spray and are to be provided with means for maintaining this quality after removal of the plug.

**8.4 Heating and cooking equipment**

**8.4.1 General**

8.4.1.1 Heaters are to be so constructed, installed and protected that clothing, bedding and other inflammable material cannot come in contact with them in such a manner as to cause risk of fire. There is to be no excessive heating of adjacent bulkheads or decks.

**8.5 Lightning conductors**

8.5.1 Lightning conductors are to be fitted to each mast of all wood, composite and steel ships having

wooden masts or topmasts. They need not be fitted to steel ships having steel masts, unless the mast is partly or completely insulated from the ship's hull.

8.5.2 Lightning conductors are to be run as straight as possible, and sharp bends in the conductors are to be avoided. All clamps used are to be of brass or copper, preferably of the serrated contact type, and efficiently locked. Soldered connections are not acceptable.

8.5.3 The resistance of the lightning conductors, measured between the mast head and the position on the earth plate or hull to which the lightning conductor is earthed, is not to exceed 0.02 ohms.

8.5.4 The lightning conductors are to be composed of continuous copper tape and/or rope, having a section not less than 100 [$mm^2$] and are to be riveted with copper rivets or fastened with copper clamps to an appropriate copper spike of not less than 13 [mm] in diameter and projecting at last 150 [mm] above the top of the mast. The lower end of the lightning conductor is to be securely clamped to a copper plate having an area of at least 0.2 [$m^2$], fixed to the ship's hull well below the light load waterline in such a manner that it is immersed under all conditions of heel. In steel ships fitted with wooden masts, the lower end of the lightning conductor is to be securely clamped to the nearest metal forming part of the hull.

## Section 9

## Trials

### 9.1 General

9.1.1 Before a new installation, or any alteration or addition to an existing installation, is put into service the tests and trials specified in this Section are to be carried out. These tests and trials are intended to demonstrate the general condition of the installation at the time of completion. They are in addition to any acceptance tests which may have been carried out at the manufacturer's works.

### 9.2 Insulation resistance measurement

9.2.1 Insulation resistance is to be measured using a self-contained instrument such as a direct reading ohm-meter of the generator type applying a voltage of at least 500 V. Where a circuit incorporates capacitors of more than 2μF total capacitance, a constant-voltage type instrument is to be used to ensure accurate test readings.

9.2.2 Power and light circuits : The insulation resistance between all insulated poles and earth and, where practicable, between poles, is to be at least 1 megaohm. The installation may be subdivided and appliances may be disconnected if initial tests produce results less than this figure.

9.2.3 Low voltage circuits : Circuits operating at less than 55 V are to have an insulation resistance of at least 0.33 megaohm.

9.2.4 Switchboards, Section boards and distribution boards : The insulation resistance is to be at least 1 megaohm when measured between each busbar and earth and between busbars. This test may be made with all circuit-breakers and switches open, all fuse links for pilot lamps, earth fault-indicating lamps, voltmeters, etc., removed and voltage coils temporarily disconnected, where otherwise damage may result.

9.2.5 Generators and motors : The insulation resistance of generators and motors, in normal working condition and with all parts in place, is to be measured and recorded. The test should be carried out with the machine hot, if possible. The insulation resistance of generator and motor cables, field windings and control gear is to be at least 1 megaohm.

### 9.3 Earth continuity

9.3.1 Tests are to be made to verify that all earth continuity conductors are effective and that the bonding and earthing of metallic conduit and/or sheathing of cables is effective.

### 9.4 Performance

9.4.1 It is to be established that the provisions of the Rules have been complied with respect to the criteria mentioned in this sub-section.

9.4.2 Temperatures of joints, connections, circuit-breakers and fuses.

9.4.3 The operation of engine governors, synchronising devices, overspeed trips, reverse-current, reverse-power, over-current and under-voltage trips and other safety devices.

9.4.4 Satisfactory commutation, excitation and performance of each generator throughout a run at full rated load.

9.4.5 Voltage regulation of every generator when full rated load is suddenly thrown off.

9.4.6 For alternating current and direct current generators, satisfactory parallel operation and [kW] load sharing of all generators capable of being operated in parallel at all loads up to normal working load. For alternating current generators satisfactory parallel operation and KVA load sharing of all generators capable of being operated in parallel at all loads up to normal working load.

9.4.7 All essential motors and other important equipment are to be operated under service conditions, though not necessarily at full load or simultaneously, for a sufficient length of time to demonstrate that they are satisfactory.

### 9.5 Voltage drop

9.5.1 Voltage drop is to be measured, where necessary, to verify that this is not excessive.

## Chapter 9
## Spare Gear

***Contents***



## Section 1
## General

### 1.1 General

1.1.1 Adequate spare parts for the propelling and essential auxiliary machinery together with necessary tools for maintenance and repair are to be readily available for use.

1.1.2 Spare parts are to be supplied and their location is to be the responsibility of the Owner but must take in to account the design and arrangements of the machinery and the intended service and operation of the ship. Account should also be taken of the recommendations of the machinery manufacturer and any applicable statutory requirements of the country of registration of the ship.

### 1.2 Table of spare parts

1.2.1 For guidance purposes spare parts for main and auxiliary machinery installations are shown in the following Tables:-

- Table 1.2.1 - Spare parts for main internal combustion engines;
- Table 1.2.2 - Spare parts for auxiliary boilers;
- Table 1.2.3 - Spare parts for auxiliary air compressors.

**Table 1.2.1 : Main internal combustion engines**

| Sr.No. | Item | Spare Part | Qty. |
|---|---|---|---|
| 1 | Main thrust block | Pads for one face of thrust block | 1 set |
| | | Complete white metal thrust shoe of solid ring type | 1 |
| | | Inner and outer race with rollers, where roller thrust bearings are fitted | 1 |
| 2 | Cylinder valves | Exhaust valves, complete with casings, seats, springs and other fittings for one cylinder | 1 set |
| | | Air inlet valves, complete with casings, seats springs and other fittings for one cylinder | 1 set |
| | | Starting air valve, complete with casing, seat, springs and other fittings | 1 |
| | | Relief valve, complete | 1 |
| | | Fuel valves of each size and type fitted complete with all fittings, for one engine | 1/4 set |
| 3 | | Special gaskets and packing of each size and type fitted for cylinder cover and cylinder liner for one cylinder | 1 set |

**Table 1.2.2 : Auxiliary boilers**

| Sr.No. | Item | Spare Part | Qty. |
|---|---|---|---|
| 1 | Tube stoppers or plugs | Tube stoppers or plugs, of each size used, for boiler superheater and economiser tubes | 10 |
| 2 | Fire bars | Fire bars for one boiler, where coal fired | Half set |
| 3 | Oil fuel burners | Oil fuel burners complete, for one boiler | 1 set |

**Table 1.2.3 : Auxiliary air compressor**

| Sr.No. | Item | Spare Part | Qty. |
|---|---|---|---|
| 1 | Piston rings | Rings of each size fitted for one piston | 1 set |
| 2 | Valves | Suction and delivery valves, complete, of each size fitted | Half set |

**Annex 4**

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**Chapter 1**

**Dry Bulk Cargo Carriers**

**Contents**

## Section 1

## General

### 1.1 Application

1.1.1 The requirements of this chapter apply to single deck vessels designed primarily for carriage of dry bulk cargoes and are supplementary to those given for the assignment of main characters of class. It is implied that the cargo loading would largely be homogeneous, without any hold being empty in fully loaded condition.

### 1.2 Documentation

1.2.1 The following additional documents are to be submitted for approval, as applicable:

a) Design values of maximum mass of bulk cargo to be carried in the vessel and total volume of holds upto top of the hatch coaming.

b) Maximum density of heavy bulk cargo envisaged and the corresponding angle of repose.

c) Details of all envisaged loading conditions clearly stating special features if any e.g. loading in heaps. Calculations of still water bending moments in all these loading conditions and also for transient conditions during loading / unloading, if more onerous, are to be submitted.

### 1.3 Design loads in cargo holds

1.3.1 Definitions

M = maximum mass [tonnes], to be carried in the vessel

V = Total volume of the holds upto the top of hatch coaming [$m^3$]

$\rho_f$ = value of maximum density of bulk cargo to be carried in the holds assuming the cargo is filed homogeneously upto the top of hatch coaming i.e. (M/V) [$t/m^3$].

$\rho_f$ is not to be taken less than the following:

= 0.8 [$t/m^3$] for vessels with class notation “Bulk carrier”.

= 1.0 [$t/m^3$] for vessels with class notation, “Bulk carrier” “Strengthened for heavy cargoes” and for “Ore carriers”.

H = height [m], from the load point to the top of hatch coaming.

$\rho_h$ = Maximum density of heavy bulk cargo envisaged [$t/m^3$].

$h_c$ = height [m], from the load point to the actual cargo surface determined by considering the corresponding hold geometry, cargo volume at density $\rho_h$ angle of repose and the loading pattern e.g. loading in heaps.

$\delta$ = angle of repose of bulk cargo in degrees, not to be taken greater than:

$\delta$ = 20° for light bulk cargo (e.g. grain, coal)

= 25° for bulk cement cargo

= 35° for heavy bulk cargo (e.g. iron ore).

1.3.2 The scantlings of inner bottom and sloping or vertical bulkhead plating and stiffeners are to be based on the cargo pressure or the flooding pressure given below, whichever is greater.

Cargo pressure, $p = 12.5\ C.q$ [$kN/m^2$]

Flooding pressure, $p = 10h$ [$kN/m^2$]

*where*,

C = 1.0 for inner bottom

$= \tan^2(45 - \delta/2)$ for vertical bulkheads

$= \sin^2\alpha\ .\ \tan^2(45° - \delta/2) + \cos^2\alpha$ for sloping bulkheads

$\alpha$ = angle of sloping bulkhead with the horizontal plane, [degrees]

$q = \rho_f\ .\ H$ [$t/m^2$], or

$= \rho_f\ .\ h_c$ [$t/m^2$]; whichever is greater.

h = vertical distance from load point to the deck at side [m].

## Section 2

## Bulk Carriers

### 2.1 Hull arrangement

2.1.1 Bulk carriers are to be constructed with two longitudinal bulkheads bounding the cargo space or with single side skin construction in association with hopperside tanks at the bottom and topside tanks fitted below the deck. Between the longitudinal bulkheads or hopperside tanks, double bottom construction is generally to be adopted. However, for vessels upto 65 [m] in length single bottom construction with floors at each frame may be accepted.

2.1.2 For vessels of $L \geq 65$ [m] longitudinal framing system is to be adopted within the cargo region on deck and in the double bottom, wing spaces or hopperside and topside tanks.

2.1.3 The number and disposition of transverse bulkheads are to be as per Annex 2 Ch.9. Additional bulkheads may have to be fitted from side to side or in wing spaces to provide sufficient transverse strength.

**2.2 Longitudinal strength**

2.2.1 The longitudinal strength is to be in accordance with the requirements given in Annex 2 Ch.4, considering the maximum of still water bending moments calculated as per 1.2.1.

**2.3 Bottom structure**

2.3.1 The scantlings and arrangements are, in general, to be as per Annex 2, Ch.6, except as given below.

2.3.2 In double bottom spaces, the spacing of plate floors and girders is generally not to exceed 2.5 [m] and 3 [m], respectively.

2.3.3 The scantlings of inner bottom and hopper side plating and stiffeners based on Annex 2, Ch.6 and design pressures given in 1.3.2 are minimum requirements. It should be noted that for vessels where cargoes are to be regularly discharged by grabs, the scantlings would require to be increased suitably to reduce the risk of local damage and erosion and are to be as per Annex 2, Ch.6, 4.2.3..

2.3.4 In addition to the requirements of Annex 2, Ch.6, the section modulus of single bottom floors in cargo holds is also to be not less than the following:

$Z = 0.006\ s\ le^2\ (\rho_f\ .\ H - 0.3T)\ \ [cm^3]$

- Where the cargo is always to be leveled

$Z = 0.006\ s\ l_e^2\ (1.25\rho_f\ .\ H - 0.3T)\ \ [cm^3]$

- Where the cargo is loaded in heaps.

*where*,

s = spacing of floors [mm]

$l_e$ = span of floors, measured between longitudinal bulkheads [m].

The strength of floors is to be maintained in way of and outboard of the connection with longitudinal bulkheads.

**2.4 Side structure – single skin**

2.4.1 The scantlings and arrangement of side shell plating and stiffening is to be, in general, as per Annex 2, Ch.7. The thickness of hold frame web and its lower bracket is not to be less than 8 [mm] and 10 [mm] respectively.

**2.5 Side structure – double skin**

The following apply to vessels where double skin structure is provided.

2.5.1 Scantlings of the longitudinal bulkhead plating and stiffening is to be as per Annex 2, Ch.9 based on the actual spacing of stiffeners and design pressure given in 1.3.2.

2.5.2 The longitudinal bulkheads are generally to have the same framing system as the side shell.

2.5.3 Where longitudinal framing is adopted, transverses supporting longitudinal are to be arranged in line with double bottom floors.

2.5.4 Where transverse framing is adopted, the section modulus of the stiffeners of side shell and longitudinal bulkhead may be reduced by 20% provided a strut is fitted at mid span of the stiffeners. The strut is to have the same cross sectional area as the greater of the members interconnected.

2.5.5 The inner bottom plating is to be extended into the wing tank structure in the form of a gusset plate, arranged to ensure a smooth structural transition in way of transverse primary members. The gusset plate is to be of sufficient width to provide effective scarfing of the inner bottom into the wing tank structure.

2.5.6 All watertight and non-watertight bulkheads in wing tanks are to be suitably reinforced in way of double bottom scarfing arrangements. Openings in wing tank bulkheads are to be kept clear of these areas.

2.5.7 Ends of longitudinal bulkheads are to be well scarfed into the fore and aft structure.

2.5.8 It is recommended that the space between the side shell and longitudinal bulkhead be adequately subdivided such that the vessel remains afloat even when one of the compartments is flooded.

**2.6 Deck structure**

2.6.1 The scantlings and arrangements of the deck structure are generally to be as per Annex 2, Ch.8.

2.6.2 The thickness of the deck plating is to be maintained over the length of hatch opening and in any case over 0.5L region amidships.

**2.7 Continuous longitudinal hatch coamings**

2.7.1 In addition to the requirements of Annex 2, Ch.4, Sec.3 and Ch.11, Sec.2; the following requirements are to be complied with.

2.7.2 Coamings are to be stiffened at the upper edge by a horizontal stiffener of substantial size. Additional longitudinal stiffeners are to be fitted on the coaming above deck to provide sufficient strength against buckling.

2.7.3 Substantial coaming stays are to be fitted generally not more than 2.0 [m] apart. Special attention is to be paid to their attachment to deck and stiffening below.

**2.8 Bulkheads**

2.8.1 The scantlings of bulkheads are to be as per Annex 2, Ch.9, taking into account the dry bulk cargo loading given in 1.3.2.

2.8.2 Where bulkheads are of corrugated construction, the angle of corrugation (i.e. of webs with the plane of bulkheads) is not to be less than 55°.

## Section 3

## Ore Carriers

### 3.1 Hull arrangement

3.1.1 Ore carriers are to be provided two longitudinal bulkheads and a double bottom in way of the cargo holds. It is assumed that only spaces between the longitudinal bulkheads are used as cargo holds.

3.1.2 The bottom and deck outside the hatch openings are to be longitudinally framed. The side shell and longitudinal bulkheads also, in general, are to be longitudinally framed.

3.1.3 In wing tanks, primary bottom structure is to be so arranged as to maintain structural continuity of the hold double bottom structure in the transverse direction.

3.1.4 Other additional requirements given in Sec.2.2 to 2.8 for bulk carriers, also apply to ore carriers.

## Chapter 2

## Tankers

**Contents**



## General

### 1.1 Application

1.1.1 This chapter applies to vessels intended for carriage of liquid cargo in tanks.

1.1.2 The requirements in this chapter are supplementary to the applicable requirements of Annex 1, 2, and 3.

## Hull Scantlings

### 2.1 General

2.1.1 Hull scantlings are to be determined as specified in Annex 2 using appropriate design loads, unless otherwise specified in this chapter.

### 2.2 Thermal Stress

2.2.1 Where heated liquids are intended to be carried in tanks, a calculation of thermal stresses is required, if carriage temperature of liquid exceeds 90 degree Celsius.

## Structural Arrangement

### 3.1 General

3.1.1 The bottom shell, inner bottom and deck are generally to be longitudinally framed in the cargo tank region. Vessels provided with transverse framing will be specially considered.

3.1.2 Inner hull and longitudinal bulkheads are to extend beyond the cargo tank region as far forward and aft as practicable and are to be effectively scarfed into the adjoining structure.

3.1.3 Primary members are to be so arranged as to ensure effective continuity of strength throughout the tank structure. Abrupt changes in depth of sections are to be avoided. Vertical webs on structure are to be arranged in line with the double bottom floors, deck transverses and vertical transverses at the longitudinal bulkheads to ensure continuity of transverse structure. Longitudinal deck girders are to be supported at transverse bulkheads by vertical webs or equivalent. The depth and scantlings of the continuous girders are to be increased in way to provide effective support. Where members abutt on both sides of bulkhead or other deeper members, the alignment of webs and faceplates are to be ensured.

### 3.2 Bottom Structure

3.2.1 Longitudinal girders are to be provided at

a) centerline (or duct keel)

b) under longitudinal bulkhead (or sloping plates of bulkhead stool in case of vertically corrugated longitudinal bulkheads)

c) under sloping plate of hopper side tank where fitted.

3.2.2 Plate floors are to be arranged in way of transverse bulkheads and sloping plates of bulkhead stools.

3.2.3 Transverse continuity of inner bottom is to be maintained outboard of inner hull.

3.2.4 Spacing of girders is to be in accordance with Part 3, Ch 6, Sec 6.3.

**3.3 Side Structure**

3.3.1 Brackets are to be provided at the ends of the crossties to connect to the transverses or girders. Transverses and vertical webs are to be fitted with tripping brackets at the junctions with cross ties. Where the width of the face plate of the cross ties exceeds 150 [mm] on any one side of the web, additional tripping brackets are to be provided to support the face plate.

3.3.2 End connections of cross-ties are to ensure adequate area of connection and may require additional bracket thickness. Full penetration welding may be required particularly in way of toes of the end brackets.

**3.4 Deck Structure**

3.4.1 A trunk deck, if fitted is to extend over the full length of the cargo tanks and is to be effectively scarfed into the main hull structure. The trunk deck and the sides are to be longitudinally framed and the transverse primary members are to be aligned with the outboard deck transverses.

3.4.2 Where external stiffening is carried in way of the trunk deck, appropriate tripping brackets are to be fitted in way of the underdeck supporting structure. The arrangement and details of the external girders will be specially considered.

**3.5 Tank Bulkheads**

3.5.1 The arrangement and stiffening of transverse oil tight bulkheads are to efficiently support the lateral liquid pressure as well as the loads transmitted by end connection of inner hull, longitudinal bulkheads, shell and deck longitudinal. Where transverse bulkheads are vertically corrugated, horizontal stringers or equivalent is to be fitted to provide adequate resistance to transverse compressive forces.

3.5.2 The top and bottom strakes of longitudinal corrugated bulkheads are to be plane over width of 0.1D from the deck and bottom. The thickness of this plating is not to be less than 75% of the adjoining deck and inner bottom plating. Stools provided for corrugated bulkheads will be specially considered.

3.5.3 Particular attention is to be paid to the through thickness properties at the connection to the deck and inner bottom.

3.5.4 Where longitudinal bulkheads are corrugated horizontally, the corrugations are to be aligned, and stiffening arrangements on plane members are to be arranged to provide adequate support in way of flanges of abutting corrugations. Where both the longitudinal and transverse bulkheads are horizontally corrugated, the ends are to be connected to ensure continuity.

3.5.5 Where horizontal girders (or vertical webs) on the transverse bulkheads do not form part of a ring structure, they are to be arranged with substantial end brackets forming a buttress extending to the adjacent vertical web (or transverse). The shear and combined stresses in the buttress arrangement is to be specially examined.

**3.6 Vessels with independent tanks**

3.6.1 The side frames may be inside or outside the tank. When tank longitudinal sides are framed vertically, stiffeners are to form continuous frames with the top and bottom stiffeners, whether the frames are connected or not by brackets.

3.6.2 The vertical or horizontal stiffeners of transverse sides are to be welded on to the perpendicular tank sides, either directly or by means of brackets extending up to the first of previous side.

3.6.3 Bottom structure is to be adequately stiffened, to ensure proper contact between tank plates and vessel bottom.

3.6.4 Fastening of Independent tanks

3.6.4.1 The tank seatings are to be constructed in such a manner so as to make it impossible for the tanks to move in relation to the vessel structure. Suitable partial girders are to be provided below this seatings.

3.6.4.2 The tanks are to be supported by the floors or bottom longitudinals.

3.6.4.3 When stringer is chocked against tanks in way of some web frames or side shell transverses, chocking may consist in a bolted assembly. Arrangements are to be provided to avoid an accidental shifting during navigation in case of applying wedges in hard wood or synthetic material capable of transmitting the chocking stress.

3.6.4.4 Anti-flotation arrangements are to be provided for independent tanks. The anti-flotation arrangements are to be suitable to withstand an upward force caused by an empty tank in a hold space flooded to the damage draught of the vessel, without plastic deformation likely to endanger the hull structure.

3.6.4.5 Strength check of the seatings and stays is to be done. Stress concentrations in the tank walls are to be avoided and care is to be taken to ensure that the tank seatings do not impede the contraction of the tank when cooled down to transport temperature.

3.6.4.6 When refrigerated cargo is carried, material used for fastening is to be suitable for the corresponding lower temperature

### 3.7 Construction Details

3.7.1 The members are to have adequate end fixity, lateral support and web stiffening, and the structure is to be arranged to minimize hard spots or other sources of stress concentration. Openings are to have well rounded corners and smooth edges and are to be located having regard to the stress distribution and buckling strength of the plate panel.

3.7.2 To maintain continuity of strength, substantial horizontal and vertical brackets are to be fitted to transverses or stringers at the ends of the cross ties. Horizontal brackets are to be aligned with the cross tie face plates, and vertical end brackets are to be aligned with the cross tie web.

3.7.3 In a ring system where the end bracket is integral with the webs of the members, and the face plate is carried continuously along the edges of the members and the bracket, the full area of the largest face plate is to be maintained upto the mid-point of the bracket and then gradually tapered to the smaller face plates. Butts in face plates are to be kept well clear of the toes of brackets.

3.7.4 The thickness of separate end brackets is generally to be not less than that of the thicker of the primary member webs being connected, but may be required to be locally increased at the toes. The bracket is to extend to adjacent tripping brackets, stiffeners or other support points. Bracket toes are to be well radiused. Where the bracket is attached to a corrugated bulkhead, the plating at the bracket toe is to be suitably reinforced.

3.7.5 Tripping brackets are generally to be fitted close to the toes of end brackets, in way of cross ties and generally at every fourth stiffener elsewhere. Arrangements should also be made to prevent tripping at the intersection with other primary members.

3.7.6 In way of cross ties and their end connections lightening holes are not to be cut in side and longitudinal bulkhead stringers. Lightening holes are also to be avoided on vertical webs on longitudinal bulkheads and in wing ballast tanks.

3.7.7 Holes cut in primary longitudinal members within 0.1D of deck and bottom are, in general to be reinforced. Where holes are cut in primary longitudinal members in areas of high stress and where primary members are of higher tensile steel, they are to be elliptical, or equivalent, to minimise stress concentration.

3.7.8 Longitudinals within the range of cargo tanks are not permitted to have closely spaced scallops except in way of ballast pipe suctions. Reinforcement in these areas will be specially considered. Small air and drain holes, cut-outs at erection butts and similar widely spaced openings are, in general not to be less than 200 [mm] clear of the toes of end brackets, intersections with primary supporting members and other areas of high stress. All openings are to be well rounded with smooth edges.

3.7.9 Where holes are cut for heating coils, the lower edge of the hole is to be not less than 100 [mm] from the inner bottom. Where large notches are cut in the transverses for the passage of longitudinal framing, adjacent to openings for heating coils, the notches for longitudinals are to be collared.

## General Requirements for Tankers Carrying Dangerous Goods

### 4.1 General

4.1.1 Application

4.1.1.1 The requirements in this section apply to tankers intended for carriage of dangerous goods in bulk.

4.1.1.2 The requirements of Inland Waterways tankers intended for the carriage of dangerous liquids in bulk are based on the United Nation's ADN regulations. The ADN are the regulations for the transport of dangerous goods.

*Refer:* *https://www.unece.org/trans/danger/publi/adn/adn_e.html*

### 4.2 Tanker types and cargo tank design types

4.2.1 Tanker Type

a) tankers complying with the requirements of Section 5, 5.4 and other relevant requirements will be **TYPE N**

b) tankers complying with the

requirements of Section5, 5.5 and other relevant requirements will be **TYPE C**

c) tankers complying with the requirements of Section 6 and other relevant requirements will be **TYPE G**

*Note: Alternative requirements to section 6 and ADN regulations as acceptable to the Designated Authority/ Classification Society may be applied for Type G*

4.2.2 Cargo Tank Design Types

**a)** pressure tank : **TANK DESIGN 1**

**b)** closed tank :**TANK DESIGN 2**

**c)** open tank with flame arresters : **TANK DESIGN 3**

**d)** open tank: **TANK DESIGN 4**

4.2.3 Cargo Tank Type

a) Independent tank: **TANK TYPE 1**

b) integral tank: **TANK TYPE 2**

c) When walls of cargo tank used are distinct from outer hull of vessel: **TANK TYPE 3**

4.2.4 Based on allowed tanker type and cargo tank configuration for the cargoes mentioned in list of cargoes, an appropriate combination of *Tanker Type, Cargo Tank Design* and *Cargo Tank Type* is to be assigned.

### 4.3 Classification of Dangerous Goods

4.3.1 Classification of dangerous goods are defined according to the UN Model Regulations.

4.3.2 The following dangerous goods of the classes listed below may be carried in tankers complying with the rules for carriage of the intended cargo:

| | |
|---|---|
| Class 2 | Gases |
| Class 3 | Flammable Liquids |
| Class 6.1 | Toxic Substances |
| Class 8 | Corrosive Substances |
| Class 9 | Miscellaneous dangerous substances and articles |

4.3.3 Products listed in the product list (see Part 3 Table C of ADN Regulations) are permitted to be carried in tankers complying with the requirements of this chapter.

### 4.4 Types of Tankers

4.4.1 Based on type of cargo carried by the tanker, a distinction can be made between three different tanker types:

a) **Type G**: means a tank vessel intended for carriage of liquefied gases. Carriage may be under pressure or under refrigeration.

b) **Type C**: means a tank vessel intended for the carriage of liquids. The vessel is to be of the flush-deck/double-hull type with double-hull spaces, double bottoms, but without trunk. The cargo tanks may be formed by the vessel's inner hull or may be installed in the hold spaces as independent tanks.

c) **Type N**: means a tank vessel intended for the carriage of liquids.

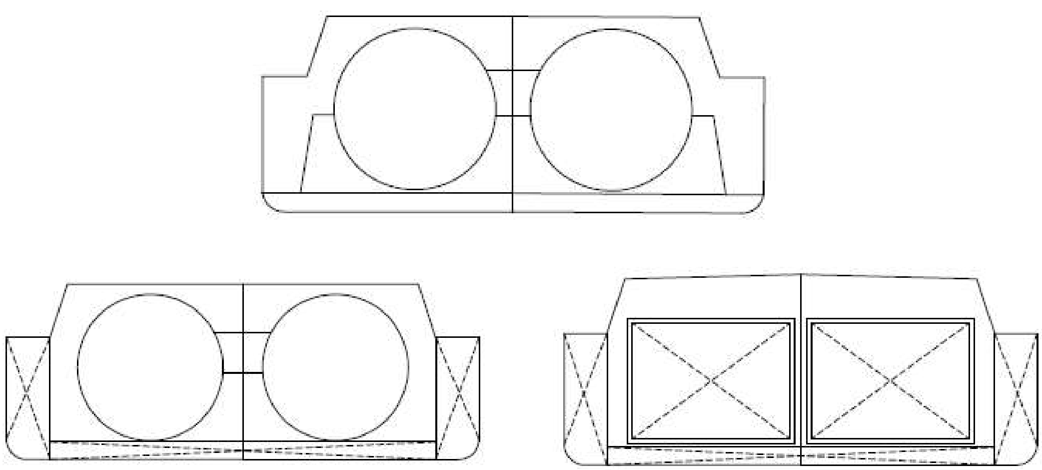


*Fig.1 : Examples of possible hull configurations for Tankers of the Type G*

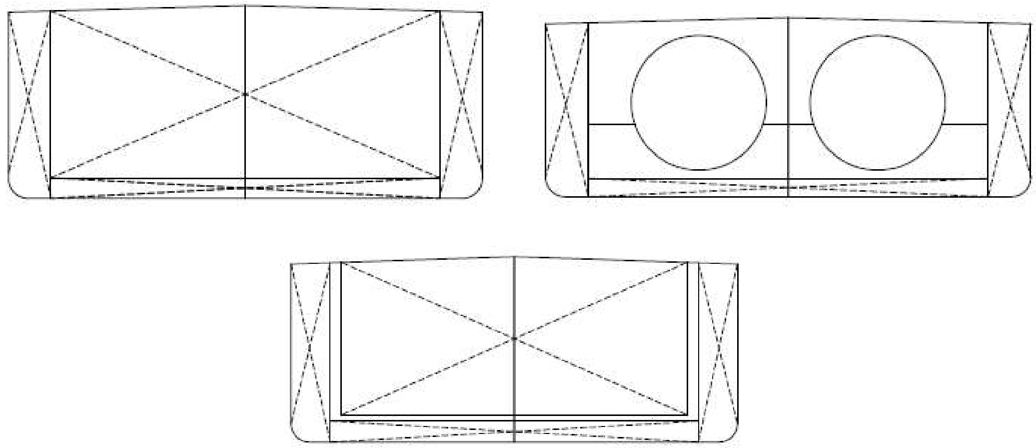


***Fig.2 : Examples of possible hull configurations for Tankers of the Type C***

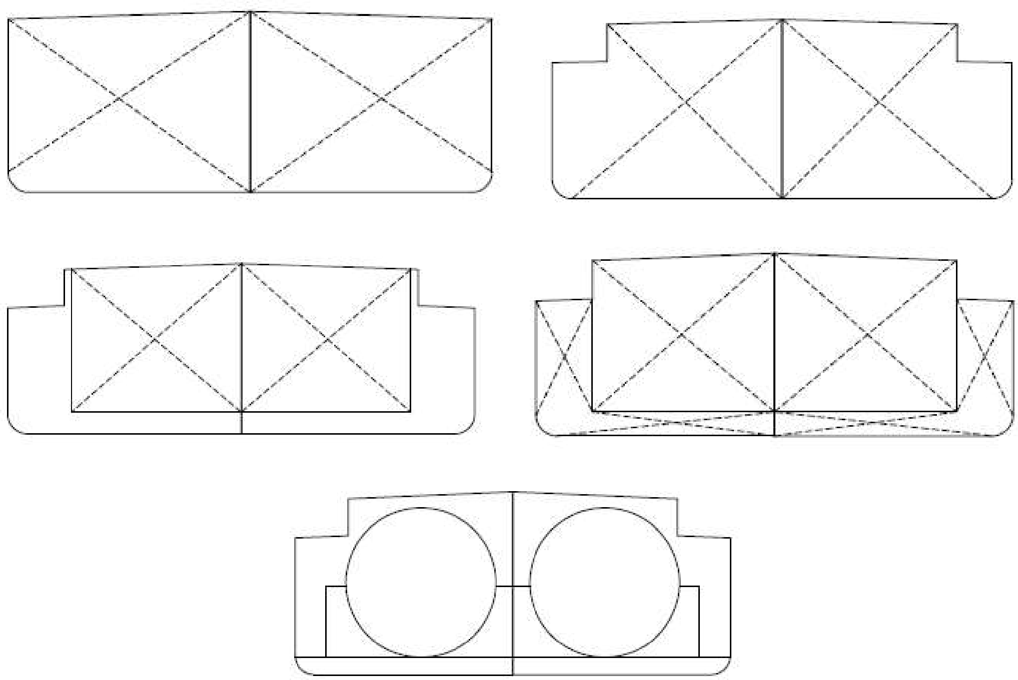


***Fig.3 : Examples of possible hull configurations for Tankers of the Type N***

4.4.2 Cargo Tank Design

a) Pressure cargo tank (see 4.8.11.1)

b) Closed cargo tank (see 4.8.11.2)

c) Open cargo tank with flame arrester (see 4.8.11.3)

d) Open cargo tank (see 4.8.11.4)

4.4.3 Cargo Tank Type

a) Independent cargo tank (see 4.8.12.1)

b) Integral cargo tank (see 4.8.12.2)

c) Cargo tank with walls distinct from the outer hull (see 4.8.12.3)

| Table 1: Variations of Cargo Tank Configurations | | | | |
|---|---|---|---|---|
| ***Type N Tankers*** | | | | |
| | | **Cargo Tank Type** | | |
| | | **Independent**<br>**TANK TYPE 1** | **Integral**<br>**TANK TYPE 2** | **Walls Distinct from outer hull**<br>**TANK TYPE 3** |
| **Cargo Tank Design** | **Pressure Tank**<br>**TANK DESIGN 1** | X | N.A | N.A |
| | **Closed Tank**<br>**TANK DESIGN 2** | X | X | X |
| | **Open Tank with flame arresters**<br>**TANK DESIGN 3** | X | X | X |
| | **Open Cargo Tank**<br>**TANK DESIGN 4** | X | X | X |
| ***Type C Tankers*** | | | | |
| | | **Independent**<br>**TANK TYPE 1** | **Integral**<br>**TANK TYPE 2** | **Walls Distinct from outer hull**<br>**TANK TYPE 3** |
| **Cargo Tank Design** | **Pressure Tank**<br>**TANK DESIGN 1** | X | N.A | N.A |
| | **Closed Tank**<br>**TANK DESIGN 2** | X | X | N.A |
| | **Open Tank with flame arresters**<br>**TANK DESIGN 3** | N.A | N.A | N.A |
| | **Open Cargo Tank**<br>**TANK DESIGN 4** | N.A | N.A | N.A |
| ***Type G Tankers*** | | | | |
| | | **Independent**<br>**TANK TYPE 1** | **Integral**<br>**TANK TYPE 2** | **Walls Distinct from outer hull**<br>**TANK TYPE 3** |
| **Cargo Tank Design** | **Pressure Tank**<br>**TANK DESIGN 1** | X | N.A | N.A |
| | **Closed Tank**<br>**TANK DESIGN 2** | X | N.A | N.A |
| | **Open Tank with flame arresters**<br>**TANK DESIGN 3** | N.A | N.A | N.A |
| | **Open Cargo Tank**<br>**TANK DESIGN 4** | N.A | N.A | N.A |

### 4.5 Designation of dangerous liquids to vessel types

#### 4.5.1 Permitted Vessels

4.5.1.1 Dangerous substances may be carried in tankers of Type N, C and G in accordance with the requirements of Sec 5, or 6. The type of vessel to be used is specified in Column (6) of Table C of Chapter 3.2 of ADN and in 4.5.2.1 to 4.5.2.7. Cargo tank design and cargo tank type to be used are mentioned in column (7) and (8) of Table C of Chapter 3.2 of ADN respectively.

| Dangerous Goods Class | Vessel Type |
|---|---|
| 2 | Gases; compressed, liquefied or dissolved under pressure are to be carried in Type G tankers. |
| 3 | Flammable liquids are generally to be carried in Type N tankers unless, depending on their properties and classification, a higher vessel type is required. Liquids for which a certain vessel type is requested may also be carried in a higher vessel type. |
| 6.1 | Poisonous (toxic) liquids are to be carried in Chemical tankers of Type C. These liquids may also be carried in Type C or G tankers respectively. |
| 8 | Corrosive liquids are generally to be carried in Tankers of Type N, having, (depending on the properties of the liquids), open integral cargo tanks or open cargo tanks independent from the vessel's structure. For some liquids, depending on their properties and classification, a higher vessel type may be required. Corrosive liquids for which a certain vessel type is requested may also be carried in a higher vessel type. |
| 9 | Liquids having a potential hazard during transport not described in the above categories are to be carried in Tankers of Type N, having, (depending on the properties of the liquids), open integral cargo tanks or open cargo tanks independent from the vessel's structure. These liquids may also be carried in tankers of Type N Closed, Type C and Type G respectively. |

#### 4.5.2 Carriage in Cargo Tanks

4.5.2.1 Substances, which according to column (6) of Table C of Chapter 3.2 of ADN, have to be carried in a tank vessel of type N, open, may also be carried in a tank vessel of

- type N, open, with flame arresters;
- type N, closed;
- types C or G provided that all conditions of carriage prescribed for tank vessels of type N, open, as well as all other conditions of carriage required for these substances in Table C of Chapter 3.2 of ADN are met.

4.5.2.2 Substances which, according to column (6) of Table C of Chapter 3.2 of ADN have to be carried in a tank vessel of type N, open, with flame-arresters, may also be carried in tank vessels of

- type N, closed, and types C or G provided that all conditions of carriage prescribed for tank vessels of type N, open, with flame arresters, as well as all other conditions of carriage required for these substances in Table C of Chapter 3.2 of ADN are met.

4.5.2.3 Substances which, according to column (6) of Table C of Chapter 3.2 of ADN have to be carried in a tank vessel of type N, closed, may also be carried in tank vessels of

- type C or G provided that all conditions of carriage prescribed for tank vessels of type N, closed, as well as all other conditions of carriage required for these substances in Table C of Chapter 3.2 of ADN are met.

4.5.2.4 Substances which, according to column (6) of Table C of Chapter 3.2 of ADN have to be carried in tank vessels of type C may also be carried in tank vessels of

- type G provided that all conditions of carriage prescribed for tank vessels of type C as well as all other conditions of carriage required for these substances in Table C of Chapter 3.2 of ADN are met.

4.5.2.5 Oily and greasy wastes resulting from the operation of the vessel may only be carried in fire-resistant receptacles, fitted with a lid, or in cargo tanks.

4.5.2.6 A substance which according to column (8) of Table C of Chapter 3.2 of ADN must be carried in cargo tank type 2 (integral cargo tank), may also be carried in a :

- cargo tank type 1 (independent cargo tank) or

- cargo tank type 3 (cargo tank with walls distinct from the outer hull) of the vessel type prescribed in Table C or a vessel type prescribed in 4.5.2.1 to 4.5.2.4, provided that all other conditions of carriage required for this substance by Table C of Chapter 3.2 of ADN are met.

4.5.2.7 A substance which according to column (8) of Table C of Chapter 3.2 of ADN must be carried in cargo tank type 3 (cargo tank with walls distinct from the outer hull), may also be carried in a :

- cargo tank type 1 (independent cargo tank) of the vessel type prescribed in Table C of Chapter 3.2 of ADN or a vessel type prescribed in 4.5.2.1 to 4.5.2.4 or in a type C vessel with cargo tank type 2 (integral cargo tank), provided that at least the conditions of carriage concerning the prescribed N type are met and all other conditions of carriage required for this substance by Table C of Chapter 3.2 of ADN or 4.5.2.1 to 4.5.2.4 are met.

4.5.2.8 All requirements for the particular substance as contained in Table C of Part 3 of the ADN are to be complied with. An approved list of defined cargoes is to be carried on board.

### 4.6 Stability

4.6.1 The intact or damage stability of tankers of Type G, C or N is to be in accordance with requirements given in the individual sections.

4.6.2 A stability booklet is to be provided containing the following details:

- General description of the vessel:

– General arrangement and capacity plans indicating the assigned use of compartments and spaces (cargo tanks, stores, accommodation, etc.);

– A sketch indicating the position of the draught marks referring to the vessel's perpendiculars;

– A scheme for ballast/bilge pumping and overflow prevention systems;

– Hydrostatic curves or tables corresponding to the design trim, and, if significant trim angles are foreseen during the normal operation of the vessel, curves or tables corresponding to such range of trim are to be introduced;

– Cross curves or tables of stability calculated on a free trimming basis, for the ranges of displacement and trim anticipated in normal operating conditions, with an indication of the volumes which have been considered buoyant;

– Tank sounding tables or curves showing capacities, centres of gravity, and free surface data for all cargo tanks, ballast tanks and compartments, drinking water and sewage water tanks and tanks containing products for the operation of the vessel;

– Lightship data (weight and centre of gravity) resulting from an inclining test or deadweight measurement in combination with a detailed mass balance or other acceptable measures. Where the above-mentioned information is derived from a sister vessel, the reference to this sister vessel is to be clearly indicated, and a copy of the approved inclining test report relevant to this sister vessel is to be included;

– A copy of the approved test report is to be included in the stability booklet;

▪ Operating loading conditions with all relevant details, such as:

▪ Lightship data, tank fillings, stores, crew and other relevant items on board (mass and centre of gravity for each item, free surface moments for liquid loads);

▪ Draughts amidships and at perpendiculars;

▪ Metacentric height corrected for free surfaces effect;

▪ Righting lever values and curve;

▪ Longitudinal bending moments and shear forces at read–out points;

▪ Information about openings (location, type of tightness, means of closure); and

▪ Information for the master;

### 4.7 Approved List of cargoes

4.7.1 Designated Authority/Classification Society will give approved list of all the

dangerous goods accepted for carriage in tankers. To the extent required for safe carriage the list can contain reservation for certain goods regarding

- the criteria for strength and stability of the vessel; and
- the compatibility of the accepted dangerous goods with all the construction materials of the vessel, including installations and equipment, which come into contact with the cargo.

4.7.2 A list of cargoes, for the carriage of which the vessel has been approved, will be attached to the Certificate of Survey.

4.7.3 Only those cargoes which are included in the approved list of cargoes may be carried.

4.7.4 An approved list of cargoes will be issued by Designated Authority/Classification Society and will be based on Table C of Part 3, Chapter 3.2 of the ADN. Parameters will include the tanker type, cargo tank design and cargo tank type as well as the characteristics of all relevant equipment fitted in the cargo zone. All relevant requirements of Table C will be used as a basis for the list, including any relevant additional requirements contained in column 20.

### 4.8 Definitions

4.8.1 **Accommodation** means spaces intended for the use of persons normally living on board, including galleys, food stores, lavatories, washrooms, bathrooms, laundries, halls, alleyways, etc., but excluding the wheelhouse.

4.8.2 **ADN** means European agreement concerning the *International Carriage of Dangerous Goods by Inland Waterways*.

4.8.3 **Bilge water** means oily water from the engine room bilges, the peak, the cofferdams and the double-hull spaces;

4.8.4 **Boil-off** means the vapour produced above the surface of a boiling cargo due to evaporation. It is caused by heat ingress or a drop in pressure;

4.8.5 **Bulkhead** means a metal wall, generally vertical, inside the vessel and which is bounded by the bottom, the side plating, a deck, the hatchway covers or by another bulkhead;

4.8.6 **Bulkhead (watertight)** means in a tank vessel: a bulkhead constructed to withstand a water pressure of 1[m] above the deck;

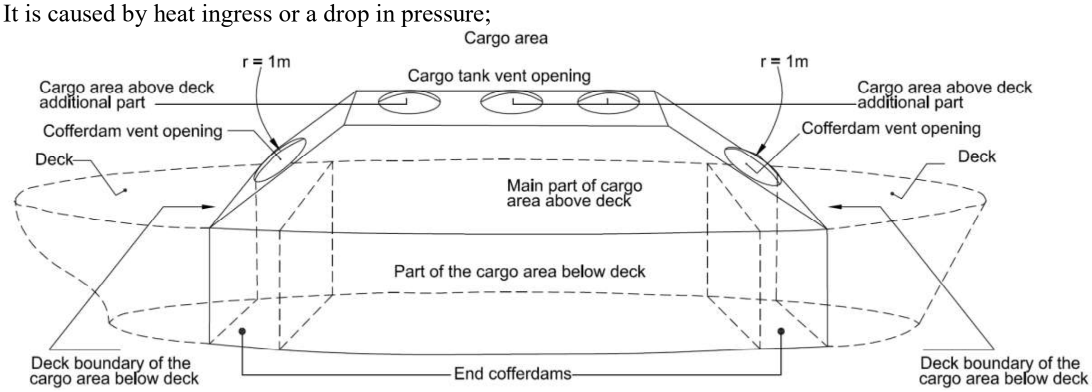
4.8.7 **Cargo area** means the whole of the following spaces( Refer to *Fig.4: Cargo Area*)

4.8.7.1 **Cargo area (additional part above deck) (when anti-explosion protection is required, comparable to Zone 1)** means the spaces not included in the main part of the cargo area above deck comprising 1 [m] radius spherical segments centred over the ventilation openings of the cofferdams and the service spaces located in the cargo area part below the deck and 2 [m] spherical segments centred over the ventilation openings of the cargo tanks and the opening of the pump-rooms.

4.8.7.2 **Cargo area (main part above deck) (when anti-explosion protection is required – comparable to Zone 1)** means the space which is bounded:

- At the sides, by the shell plating extending upwards from the deck sides
- Fore and aft, by planes inclined at 45˚ towards the cargo area, starting at the boundary of the cargo area part below deck
- Vertically, 3 [m] above the deck

4.8.7.3 **Cargo area (part below deck)** means the space between two vertical planes perpendicular to the centre-line plane of the vessel, which comprises cargo tanks, hold spaces, cofferdams, double-hull spaces and double bottom; these planes normally coincide with the outer cofferdam bulkheads or hold end bulkheads. Their intersection line with the deck is refers to as the boundary of the cargo area part below deck.



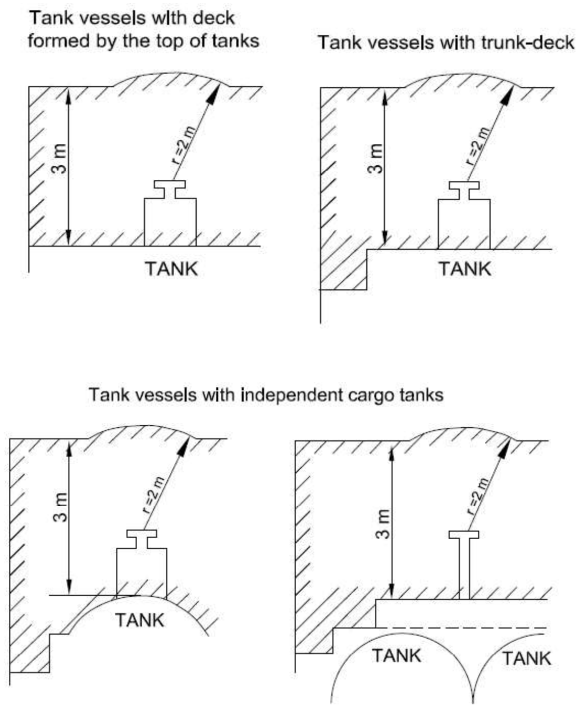



*Fig.4: Cargo Area*

4.8.8 **Cargo pump room (when anti-explosion protection is required, comparable to Zone 1)** means a service space where the cargo pumps and stripping pumps are installed together with their operational equipment.

4.8.9 **Cargo residues** means liquid cargo which cannot be pumped out of the cargo tanks or piping by means of the stripping system.

4.8.10 **Cargo tank (when anti-explosion protection is required, comparable to zone 0)** means a tank which is permanently attached to the vessel and intended for the carriage of dangerous goods.

**4.8.11** **Cargo Tank Design**

4.8.11.1 **Pressure cargo tank** means a cargo tank independent of the vessel's hull, built according to dedicated recognized standards for a working pressure ≥ 400 [kPa]

4.8.11.2 **Closed cargo tank** means a cargo tank connected to the outside atmosphere through a device preventing unacceptable overpressure or under pressure

4.8.11.3 **Open cargo tank with flame arrester** means a cargo tank connected to the outside atmosphere through a device fitted with a flame arrester.

4.8.11.4 **Open cargo tank** means a cargo tank in open connection with the outside atmosphere.

**4.8.12** **Cargo tank type**

4.8.12.1 **Independent cargo tank** means a cargo tank which is permanently built in, but which is independent of the vessel's structure.

4.8.12.2 **Integral cargo tank** means a cargo tank which is constituted by the vessel's structure itself and bounded by the outer hull or by walls separate from the outer hull.

4.8.12.3 **Cargo tank with wall distinct from the outer hull** means an integral cargo tank of which the bottom and side walls do not form the outer hull of the vessel or an independent cargo tank.

4.8.13 **Classification of zones** (*see* IEC publication 79-10, EU directive 1999/92/CE ):

- Zone 0: areas in which dangerous explosive atmospheres of gases, vapours or sprays exist permanently or during long periods;
- Zone 1: areas in which dangerous explosive atmospheres of gases, vapours or sprays are likely to occur occasionally;
- Zone 2: areas in which dangerous explosive atmospheres of gases, vapours or sprays are likely to occur rarely and, if so, for short periods only.

4.8.14 **Certified safe type electrical apparatus** means an electrical apparatus which has been tested and approved by the competent authority regarding its safety of operation in an explosive atmosphere, e.g.

- intrinsically safe apparatus;
- flameproof enclosure apparatus;
- apparatus protected by pressurization;
- powder filling apparatus;
- apparatus protected by encapsulation;
- increased safety apparatus.

4.8.15 **Cofferdam** (when anti-explosion protection is required, comparable to zone 1) means an athwartship compartment which is bounded by watertight bulkheads and which can be inspected. The cofferdam is to extend over the whole area of the end bulkheads of the cargo tanks. The bulkhead not facing the cargo area is to extend from one side of the vessel to the other and from the bottom to the deck in one frame plane.

4.8.16 **Deflagration** means an explosion which propagates at subsonic speed (see EN 13237:2011);

4.8.17 **Design pressure** means the pressure on the basis of which the cargo tank or the residual cargo tank has been designed and built.

4.8.18 **Detonation** means an explosion which propagates at supersonic speed and is characterized by a shock-wave (see EN 13237:2011);

4.8.19 **Explosion** means a sudden reaction of oxidation or decomposition with an increase in temperature or in pressure or both simultaneously (see EN 13237:2011);

4.8.20 **Flame arrester** means a device mounted in the vent of part of an installation or in the interconnecting piping of a system of installations, the purpose of which is to permit flow but prevent the propagation of a flame front. This device is to be tested according to the European standard EN ISO 16852:2010;

4.8.21 **Flame arrester plate stack** means the part of the flame arrester the main purpose of which is to prevent the passage of a flame front;

4.8.22 **Flame arrester housing** means the part of a flame arrester the main purpose of which is to form a suitable casing for the flame arrester plate stack and ensure a mechanical connection with other systems;

4.8.23 **Flash-point** means the lowest temperature of a liquid at which its vapours form a flammable mixture with air.

4.8.24 **Gas** (for the purposes of Class 2) means a substance which:

a) at 50 [° C] has a vapour pressure greater than 300 [kPa] (3 bar); or

b) is completely gaseous at 20 [° C] under standard pressure of 101.3 [kPa];

Otherwise, **Gases** means gases or vapours;

4.8.25 **Gas detection system** means a fixed system capable of detecting in time significant concentrations of flammable gases given off by the cargoes at concentrations below the lower explosion limit and capable of activating the alarms;

4.8.26 **High-velocity vent valve** means a pressure relief valve designed to have nominal flow velocities which exceed the flame velocity of the flammable mixture, thus preventing flame transmission. This type of installation is to be tested in accordance with standard EN ISO 16852:2010;

4.8.27 **Identification number** means the number for identifying a substance to which no UN number has been assigned or which cannot be classified under a collective entry with a UN number. These numbers have four figures beginning with 9.

4.8.28 **Liquid** means a substance which at 50 [° C] has a vapour pressure of not more than 300 [kPa] (3 bar) which is not completely gaseous at 20 [° C] and 101.3 [kPa], and which:

a) has a melting point or initial melting point of 20 [° C] or less at a pressure of 101.3 [kPa], or

b) is liquid according to the ASTM D 4359-90 test method or

c) is not pasty according to the criteria applicable to the test for determining fluidity (penetrometer test)

4.8.29 **Loading instrument:** A loading instrument consists of a computer (hardware) and a programme (software) and offers the possibility of ensuring that in every ballast or loading case:

- the permissible values concerning longitudinal strength as well as the maximum permissible draught are not exceeded; and
- the stability of the vessel complies with the requirements applicable to the vessel. For this purpose, intact stability and damage stability are to be calculated.

4.8.30 **Maximum working pressure** means the maximum pressure occurring in a cargo tank or a residual cargo tank during operation. This pressure equals the opening pressure of high velocity vent valves.

4.8.31 **Naked light** means a source of light using a flame which is not enclosed in a flameproof enclosure.

4.8.32 **Opening pressure** means the pressure referred to in a list of substances at which the high velocity vent valves open.

4.8.33 **Packing group** means a group to which, for packing purposes, certain substances may be assigned in accordance with their degree of danger. The packing groups have the following meanings which are explained in a more detailed manner in Part 2 of the ADN:

- Packing group I: Substances presenting high danger;
- Packing group II: Substances presenting medium danger; and
- Packing group III: Substances presenting a lower danger.

4.8.34 **Pressure relief device** means a spring-loaded device which is activated automatically by pressure the purpose of which is to protect the cargo tank against unacceptable excess internal pressure;

4.8.35 **Pressure receptacle** means a collective term that includes cylinders, tubes, pressure drums, closed cryogenic receptacles, metal hydride storage systems, bundles of cylinders and salvage pressure receptacles;

4.8.36 **Pressures.** For tanks, all kinds of pressures (e.g. working pressure, opening pressure of the high velocity vent valves, test pressure) are to be expressed as gauge pressures in kPa (bar); the vapour pressure of substances, however, is to be expressed as an absolute pressure in kPa (bar).

4.8.37 **Receptacle** means a containment vessel for receiving and holding substances or articles, including any means of closing. This definition does not apply to shells (see also Cryogenic receptacle, Inner receptacle, Rigid inner receptacle and Gas cartridge);

4.8.38 **Receptacle for residual products** means a tank, intermediate bulk container or tank-container or portable tank intended to collect residual cargo, washing water, cargo residues or slops which are suitable for pumping;

4.8.39 **Receptacle for slops** means a steel drum intended to collect slops which are unsuitable for pumping;

4.8.40 **Safety valve** means a spring-loaded device which is activated automatically by pressure the purpose of which is to protect the cargo tank against unacceptable excess internal pressure or negative internal pressure (see also, High velocity vent valve, Pressure-relief device and Vacuum valve);

4.8.41 **Service space** means a space which is accessible during the operation of the vessel and which is neither part of the accommodation nor of the cargo tanks, with the exception of the forepeak and after peak, provided no machinery has been installed in these latter spaces;

4.8.42 **Slops** means a mixture of cargo residues and washing water, rust or sludge which is either suitable or not suitable for pumping;

4.8.43 **Tanker.** A vessel which has been specially designed and constructed for the carriage of liquids or gases in bulk.

4.8.44 **Test pressure** means the pressure at which a cargo tank, a residual cargo tank, a cofferdam or the loading and unloading pipes is to be tested prior to being brought into service for the first time and subsequently regularly within prescribed times.

4.8.45 **UN number** means the four-figure identification number of the substance or article as indicated in the United Nations Model Regulations

4.8.46 **Water film** means a deluge of water for protection against brittle fracture;

4.8.47 **Water spray system** means an on-board installation that, by means of a uniform distribution of water, is capable of protecting all the vertical external surfaces of the vessel's hull fore and aft, all vertical surfaces of superstructures and deckhouses and deck surfaces above the superstructures, engine rooms and spaces in which combustible materials may be stored. The capacity of the water spray system for the area to be protected should be at least 10 [$l/m^2$ per minute]. The water spray system is to be designed for full-year use. The spray system should be operable from the wheelhouse and the safe area;

## Vessels Carrying Dangerous Cargoes in Liquid State

## (Type N & C Vessels)

### 5.1 Application

5.1.1 This section applies to propelled and non-propelled tankers of Types C, N Closed, N Open with flame arrestors and N Open, in general, intended for the carriage of dangerous liquid oil and chemical cargoes of Classes 3, 6.1, 8 and 9 in bulk.

### 5.2 Documents to be submitted

5.2.1 Following plans and documents are to be submitted in addition to the documentation required in the other Parts of the Rules for the parts of the vessel not affected by the cargo, as applicable.

5.2.1.1 Documents for Approval

a) Ventilation duct arrangement in gas-dangerous spaces and adjacent zones

b) Details of hull structure in way of cargo tanks, including support arrangement for tanks, saddles, anti-floating and anti-lifting devices, deck sealing arrangements, independent cargo tanks, etc.

c) Intact and damage stability calculations

d) Scantlings, material and arrangement of the cargo containment system.

e) Details of cargo handling system, including arrangements and details of piping and fittings

f) Details of cargo pumps

g) Details of temperature and pressure control systems

h) Bilge and ballast system in cargo area

i) Gas freeing system in cargo tanks including inert gas system

j) Ventilation system in cargo area

k) Details of electrical equipment installed in cargo area, including the list of certified safe equipment and apparatus and electrical bonding of cargo tanks and piping

l) Schematic electrical wiring diagram

m) Pressure drop calculation note

n) Gas detection system

o) Cargo tank instrumentation

p) Details of fire-extinguishing appliances and systems in cargo area

q) Arrangement drawing of the various fire bulkheads and decks with standard fire test reports for the various arrangements, surface coverings, paints and similar

r) Gas return system

5.2.1.2 Documents for Information

a) Design characteristics of products to be carried, including maximum vapour pressure, maximum liquid cargo temperature and other important design conditions

b) General arrangement plan, showing location of cargo tanks and fuel oil, ballast and other tanks, void spaces

c) Loading and unloading operation description, including cargo tank filling limits, where applicable

### 5.3 Materials of Construction

5.3.1 Materials and grades of steel are to comply with the requirements of Part 2 Inspection and Testing of Materials and as required by the individual vessel type. The independent cargo tanks may also be constructed of other materials, provided these have at least equivalent properties and resistance against the effects of temperature and fire.

5.3.2 Every part of the vessel including any installation and equipment which may come into contact with the cargo is to consist of materials which can neither be dangerously affected by the cargo nor cause decomposition of the cargo or react with it so as to form harmful or hazardous products. In case this aspect has not been examined during inspection of the vessel a relevant reservation is to be entered in the list of cargoes.

5.3.3 Venting piping is to be protected against corrosion.

5.3.4 The use of wood, aluminium alloys or plastic materials within the cargo area is prohibited except where explicitly permitted as below or in the certificate of approval

- The use of wood, aluminium alloys or plastic materials within the cargo area is only permitted for:
    - gangways and external ladders;

- movable items of equipment (aluminium gauging rods are, however permitted, provided that they are fitted with brass feet or protected in another way to avoid sparking);
- chocking of cargo tanks which are independent of the vessel's hull and chocking of installations and equipment;
- masts and similar round timber;
- engine parts;
- parts of the electrical installation;
- loading and unloading appliances;
- lids of boxes which are placed on the deck.

- The use of wood or plastic materials within the cargo area is only permitted for:
  - supports and stops of any kind.
- The use of plastic materials or rubber within the cargo area is only permitted for:
  - coating of cargo tanks and of piping for loading and unloading;
  - all kinds of gaskets (e.g. for dome or hatch covers);
  - electric cables;
  - hose assemblies for loading and unloading;
  - insulation of cargo tanks and of piping for loading and unloading;
  - photo-optical copies of the certificate of approval.
- All permanently fitted materials in the accommodation or wheelhouse, with the exception of furniture, are not to readily ignite. They are not to evolve fumes or toxic gases in dangerous quantities, if involved in a fire.

5.3.5 The paint used in the cargo area is not to be liable to produce sparks in case of impact.

5.3.6 To avoid corrosive attack of the cargo tank structure by chemical cargoes, it is strongly recommended the structure be protected by suitable lining or coating.

5.3.7 The suitability of the lining or coating and its compatibility with the intended cargoes is the responsibility of the Builder and Owner. Designated Authority will require the confirmation of the manufacturer that the lining or coating used to protect the cargo tank structure is compatible with the cargoes mentioned in list of cargoes.

**5.4 Requirements for Type N Tankers**

5.4.1 General

5.4.1.1 Application

5.4.1.1.1 Requirements of this subsection are applicable to Type N tankers.

5.4.2 Arrangement

5.4.2.1 Protection against the penetration of gases - Type N closed and Type N open with flame arrester

5.4.2.1.1 The vessel is to be designed so as to prevent gases from penetrating into the accommodation and the service spaces.

5.4.2.1.2 Outside the cargo area, the lower edges of door-openings in the sidewalls of superstructures and the coamings of access hatches to under-deck spaces are to have a height of not less than 0.50 [m] above the deck. This requirement need not be complied with if the wall of the superstructures facing the cargo area extends from one side of the vessel to the other and has doors the sills of which have a height of not less than 0.50 [m]. The height of this wall is not to be less than 2.00 [m]. In this case, the lower edges of door-openings in the sidewalls of superstructures and of coamings of access hatches behind this wall are to have a height of not less than 0.10 [m]. The sills of engine room doors and the coamings of its access hatches are to, however, always have a height of not less than 0.50 [m].

5.4.2.1.3 In the cargo area, the lower edges of door-openings in the sidewalls of superstructures are to have a height of not less than 0.50 [m] above the deck and the sills of hatches and ventilation openings of

premises located under the deck are to have a height of not less than 0.50 [m] above the deck. This requirement does not apply to access openings to double-hull and double bottom spaces.

5.4.2.1.4 The bulwarks, foot-rails, etc. are to be provided with sufficiently large openings which are located directly above the deck.

5.4.2.2 Ventilation

5.4.2.2.1 General

5.4.2.2.1.1 Each hold space is to have two openings. The dimensions and location of these openings are to be such as to permit effective ventilation of any part of the hold space. If there are no such openings, it is to be possible to fill the hold spaces with inert gas or dry air.

5.4.2.2.1.2 Double-hull spaces and double bottoms within the cargo area which are not arranged for being filled with ballast water, hold spaces and cofferdams, are to be provided with ventilation systems.

5.4.2.2.1.3 Any service spaces located in the cargo area below deck are to be provided with a system of forced ventilation with sufficient power for ensuring at least 20 changes of air per hour based on the volume of the space. The ventilation exhaust ducts are to be located up to 50 [mm] above the bottom of the service space. The fresh air inlets are to be located in the upper part; they are not to be less than 2.0 [m] above the deck, not less than 2.0 [m] from the openings of the cargo tanks and not less than 6.0 [m] from the outlets of safety valves. The extension pipes which may be necessary may be of the hinged type. On board open type N vessels other suitable installations without ventilator fans are sufficient.

5.4.2.2.1.4 Ventilation of accommo-dation and service spaces is to be possible.

5.4.2.2.2 Additional requirements for Type N closed and Type N open with flame arrester

5.4.2.2.2.1 Ventilators used in the cargo area are to be designed so that no sparks may be emitted on contact of the impeller blades with the housing and no static electricity may be generated.

5.4.2.2.2.2 Notice boards are to be fitted at the ventilation inlets indicating the conditions when they are to be closed. All ventilation inlets of accommodation and service spaces leading outside are to be fitted with fire flaps. Such ventilation inlets are to be located not less than 2 [m] from the cargo area. Ventilation inlets of service spaces in the cargo area below deck may be located within such area.

5.4.2.2.2.3 The flame-arresters pre-scribed in 5.4.2.6.4.1, 5.4.3.2.3, 5.4.3.2.4.2, 5.4.3.2.4.3, 5.4.8.4, 5.4.8.5, 5.4.8.6 and 5.4.8.7 are to be type approved for this purpose.

5.4.2.3 Engine rooms

5.4.2.3.1 Internal combustion engines for the vessel's propulsion as well as internal combustion engines for auxiliary machinery are to be located outside the cargo area. Entrances and other openings of engine rooms are to be at a distance of not less than 2.0 [m] from the cargo area. The engine rooms are to be accessible from the deck; the entrances are not to face the cargo area.

5.4.2.3.2 The hinges are to face the cargo area when the doors are not located in a recess whose depth is at least equal to the door width.

5.4.2.4 Accommodation and Service Spaces

5.4.2.4.1 Accommodation spaces and the wheelhouse are to be located outside the cargo area forward of the fore vertical plane or abaft the aft vertical plane bounding the part of cargo area below deck. Windows of the wheelhouse which are located not less than 1.0 [m] above the bottom of the wheelhouse may tilt forward.

5.4.2.4.2 Entrances to spaces and openings of superstructures are not to face the cargo area. Doors opening outward and not located in a recess the depth of which is at least equal to the width of the doors are to have their hinges facing the cargo area.

5.4.2.4.3 Entrances from the deck and openings of spaces facing the weather are to be capable of being closed. The following instruction is to be displayed at the entrance of such spaces:

**"DO NOT OPEN DURING LOADING, UNLOADING OR GAS-FREEING WITHOUT PERMISSION.**

**CLOSE IMMEDIATELY."**

5.4.2.4.4 Entrances and windows of superstructures and accommodation spaces which can be opened as well as other openings of these spaces are to be located not less than 2.0 [m] from the cargo area. Wheelhouse doors and windows are not to be located within 2.0 [m] from the cargo area, except when there is no direct connection between the wheelhouse and the accommodation.

5.4.2.4.5 Penetrations

5.4.2.4.5.1 Driving shafts of the bilge or ballast pumps may penetrate through the bulkhead between the service space and the engine room, provided the arrangement of the service space is in compliance with 5.4.3.1.13 and 5.4.3.1.14.

5.4.2.4.5.2 The penetration of the shaft through the bulkhead is to be gastight and is to be approved.

5.4.2.4.5.3 The necessary operating instructions are to be displayed.

5.4.2.4.5.4 Penetrations through the bulkhead between the engine room and the service space in the cargo area, and the bulkhead between the engine room and the hold spaces may be provided for electrical cables, hydraulic and piping for measuring, control and alarm systems, provided that the penetrations are approved. The penetrations are to be gastight. Penetrations through a bulkhead with an "A-60" fire protection insulation are to have an equivalent fire protection.

5.4.2.4.5.5 Pipes may penetrate the bulkhead between the engine room and the service space in the cargo area provided that these are pipes between the mechanical equipment in the engine room and the service space which do not have any openings within the service space and which are provided with shut-off devices at the bulkhead in the engine room.

5.4.2.4.5.6 Notwithstanding **Error! eference source not found.**, pipes from the engine room may pass through the service space in the cargo area or a cofferdam or a hold space or a double hull space to the outside provided that within the service space or cofferdam or hold space or double-hull space they are of the thick-walled type and have no flanges or openings.

5.4.2.4.6 Additional requirements for Type N closed and Type N open with flame arrester

5.4.2.4.6.1 Where a driving shaft of auxiliary machinery penetrates through a wall located above the deck the penetration is to be gastight.

5.4.2.4.6.2 A service space located within the cargo area below deck is not to be used as a cargo pump room for the loading and unloading system, except where:

- the cargo pump-room is separated from the engine room or from service spaces outside the cargo area by a cofferdam or a bulkhead with an "A-60" fire protection insulation, or by a service space or a hold space
- the "A-60" bulkhead required above does not include penetrations referred to in 5.4.2.4.5.1
- ventilation exhaust outlets are located not less than 6.0 [m] from entrances and openings of the accommodation and service spaces outside the cargo area
- the access hatches and ventilation inlets can be closed from the outside
- all pipes for loading and unloading as well as those of stripping systems are provided with shut-off devices at the pump suction side in the cargo pump-room immediately at the bulkhead. The necessary operation of the control devices in the pump room, starting of pumps and necessary control of the liquid flow rate is to be effected from the deck

- the bilge of the cargo pump-room is equipped with a gauging device for measuring the filling level which activates a visual and audible alarm in the wheelhouse when liquid is accumulating in the cargo pump-room bilge
- the cargo pump room is provided with a permanent gas detection system which automatically indicates the presence of explosive gases or lack of oxygen by means of direct-measuring sensors and which actuates a visual and audible alarm when the gas concentration has reached 20% of the lower explosive limit. The sensors of this system are to be placed at suitable positions at the bottom and directly below the deck. Measurement is to be continuous. The audible and visual alarms are installed in the wheelhouse and in the cargo pump room and, when the alarm is actuated, the loading and unloading system is shut down. Failure of the gas detection system is to be immediately signalled in the wheelhouse and on deck by means of audible and visual alarms
- the ventilation system prescribed in **Error! eference source not found.** has a capacity of not less than 30 changes of air per hour based on the total volume of the service space.

5.4.2.4.6.3 The following instruction is to be displayed at the entrance of the cargo pump room:

**" BEFORE ENTERING THE CARGO PUMP-ROOM CHECK WHETHER IT IS FREE FROM GASES AND CONTAINS SUFFICIENT OXYGEN.**

**DO NOT OPEN DOORS AND ENTRANCE OPENINGS WITHOUT PERMISSION.**

**LEAVE IMMEDIATELY IN EVENT OF ALARM."**

5.4.2.5 Inerting Facility

5.4.2.5.1 In cases in which inerting or blanketing of the cargo is prescribed, the vessel is to be equipped with an inerting system.

5.4.2.5.2 This system is to be capable of maintaining a permanent minimum pressure of 7 [kPa] (0.07 bar) in the spaces to be inerted. In addition, the inerting system is not to increase the pressure in the cargo tank to a pressure greater than that at which the pressure valve is regulated. The set pressure of the vacuum-relief valve is to be 3.5 [kPa] (0.035 bar).

5.4.2.5.3 A sufficient quantity of inert gas for loading or unloading is to be carried or produced on board if it is not possible to obtain it on shore. In addition, a sufficient quantity of inert gas to offset normal losses occurring during carriage is to be on board.

5.4.2.5.4 The premises to be inerted are to be equipped with connections for introducing the inert gas and monitoring systems so as to ensure the correct atmosphere on a permanent basis.

5.4.2.5.5 When the pressure or the concentration of inert gas in the gaseous phase falls below a given value, this monitoring system is to activate an audible and visible alarm in the wheelhouse. When the wheelhouse is unoccupied, the alarm is also to be audible in a location occupied by a crew member.

5.4.2.6 Cofferdam Arrangements

5.4.2.6.1 Cofferdams or cofferdam compartments remaining once a service space has been arranged in accordance with 5.4.3.1.13 and 5.4.3.1.14 are to be accessible through an access hatch.

5.4.2.6.2 Cofferdams are to be capable of being filled with water and emptied by means of a pump. Filling is to be effected within 30 minutes. These requirements are not applicable when the bulkhead between the engine room and the cofferdam comprises fire-protection insulation "A- 60". The cofferdams

are not to be fitted with inlet valves.

5.4.2.6.3 No fixed pipe is to permit connection between a cofferdam and other piping of the vessel outside the cargo area.

5.4.2.6.4 Additional requirements for Type N closed and Type N open with flame arrester

5.4.2.6.4.1 When the list of substances on the vessel contains substances for which protection against explosion is required in column (17) of Table C of Chapter 3.2 of ADN, the ventilation openings of cofferdams are to be fitted with a flame-arrester withstanding a deflagration

5.4.2.7 Engines

~~5.4.2.7.1~~ Only internal combustion engines running on fuel with a flashpoint of more than 55 [°C] are allowed.

5.4.2.7.2 Ventilation inlets of the engine room and, when the engines do not take in air directly from the engine room, the air intakes of the engines are to be located not less than 2 [m] from the cargo area.

5.4.2.7.3 Sparking is not to be possible within the cargo area.

5.4.2.7.4 The surface temperature of the outer parts of engines used during loading or unloading operations, as well as that of their air inlets and exhaust ducts are not to exceed the allowable temperature according to the temperature class of the substances carried. This provision does not apply to engines installed in service spaces provided the provisions of 5.4.9.3.7 are fully complied with.

5.4.2.7.5 The ventilation in the closed engine room is to be designed so that, at an ambient temperature of 20 [°C], the average temperature in the engine room does not exceed 40 [°C].

5.4.2.8 Oil fuel tanks

5.4.2.8.1 When the vessel is provided with hold spaces, the double bottoms within these spaces may be arranged as oil fuel tanks, provided their depth is not less than 0.6 [m]. Oil fuel pipes and openings of such tanks are not permitted in the hold space.

5.4.2.8.2 The open ends of the air pipes of oil fuel tanks are to extend to 0.5 [m] above the open deck. Their open ends and the

open ends of overflow pipes leading on the deck are to be provided with a protective device consisting of a gauze diaphragm or a perforated plate.

5.4.2.9 Exhaust pipes

5.4.2.9.1 Exhausts are to be evacuated from the vessel into the open air either upwards through an exhaust pipe or through the shell plating. The exhaust outlet is to be located not less than 2 [m] from the cargo area. The exhaust pipes of engines are to be arranged so that the exhausts are led away from the vessel. The exhaust pipes are not to be located within the cargo area.

5.4.2.9.2 Exhaust pipes are to be provided with a device preventing the escape of sparks, e.g. spark arresters.

5.4.2.10 Bilge pumping and ballasting arrangements

5.4.2.10.1 Bilge and ballast pumps for spaces within the cargo area are to be installed within such area.

This provision does not apply to:

- double hull spaces and double bottoms which do not have a common boundary wall with the cargo tanks;
- cofferdams, double hull spaces, hold spaces and double bottoms where ballasting is carried out using the piping of the fire fighting system in the cargo area and bilge pumping is performed using eductors.

5.4.2.10.2 Where the double bottom is used as oil fuel tank, it is not to be connected to the bilge piping system.

5.4.2.10.3 Where the ballast pump is installed in the cargo area, the standpipe and its outboard connection for suction of ballast water is to be located within the cargo area but outside the cargo tanks.

5.4.2.10.4 A cargo pump-room below deck is to be capable of being drained in an emergency by an installation located in the cargo area and independent from any other installation. This installation is to be provided outside the cargo pump room.

5.4.3 Cargo Containment

5.4.3.1 Cargo Tanks

5.4.3.1.1 The maximum permissible capacity of a cargo tank is to be determined in accordance with the following table

| Table 2 : Tank Sizes | |
|---|---|
| *Loa* x *Boa* x *D*, in $m^3$ | Maximum permissible capacity of a cargo tank ($m^3$) |
| ≤ 600 | *Loa* x *Boa* x *D* x 0.3 |
| 600 – 3750 | 180 + (*Loa* x *Boa* x *D* – 600) x 0.0635 |
| > 3750 | 380 |

where:

$L_{OA}$ X $B_{OA}$ X D : Product of the tank vessel main dimensions, in [$m^3$]

$L_{OA}$ : overall length of the hull, in [m]

$B_{OA}$ : extreme breadth in [m]

D : Shortest vertical distance between the top of the keel and the lowest point of the deck at the side of the vessel; (moulded depth) within the cargo area in [m].

In the case of trunk deck vessels, D' is to be substituted for D.

D' is to be determined by the following formula:

$$\boldsymbol{D' = D + \left(h_t \times \frac{b_t}{B} \times \frac{l_t}{L}\right)}$$

Where,

$h_t$: Height, in [m], of trunk (distance between trunk deck and main deck on trunk side measured at $L_{OA}/2$)

$b_t$ : Trunk breadth, in [m]

$l_t$ : Trunk length, in [m]

5.4.3.1.2 Alternative constructions in compliance with Chapter 9, 9.3.4 of ADN are acceptable..

5.4.3.1.3 The relative density of the substance to be carried is to be taken into consideration in the design of the cargo tanks. The maximum relative density will be indicated in the class certificate.

5.4.3.1.4 When the vessel is provided with pressure tanks, these tanks are to be designed for working pressure of 400 [kPa]

5.4.3.1.5 The cargo tank is to comply with the following:

- for vessels with a length not more than 50 [m], the length of a cargo tank is not to exceed 10 [m]
- for vessels with a length of more than 50 [m], the length of a cargo tank is not to exceed 0.2 L, where L is the vessel rule length.

This provision does not apply to vessels with independent built-in cylindrical tanks having a length to diameter ratio ≤ 7

5.4.3.1.6 The cargo tanks independent of the vessel's hull are to be fixed so that they cannot float.

5.4.3.1.7 The capacity of a suction well is to be limited to not more than 0.10 [$m^3$].

5.4.3.1.8 The cargo tanks are to be separated by cofferdams of at least 0.60 [m] in width from the accommodation, engine room and service spaces outside the cargo area below deck or, if there are no such accommodation, engine room and service spaces, from the vessel's ends. Where the cargo tanks are installed in a hold space, a space of not less than 0.50 [m] is to be provided between such tanks and the end bulkheads of the hold space. In this case an insulated end bulkhead meeting the definition for

Class “A-60”, is deemed equivalent to a cofferdam. For pressure cargo tanks, the 0.50 [m] distance may be reduced to 0.20 [m].

5.4.3.1.9 Hold spaces, cofferdams and cargo tanks are to be capable of being inspected.

5.4.3.1.10 All spaces in the cargo area are to be capable of being ventilated. Means for checking their gas-free condition are to be provided.

5.4.3.1.11 The bulkheads bounding the cargo tanks, cofferdams and hold spaces are to be watertight. The cargo tanks and the bulkheads bounding the cargo area are to have no openings or penetrations below deck. The bulkhead between the engine room and the cofferdam or service space in the cargo area or between the engine room and a hold space may be fitted with penetrations provided that they conform to the provisions of 5.4.2.4.5 and 5.4.2.4.6.1(if applicable). The bulkhead between the cargo tank and the cargo pump room below deck may be fitted with penetrations provided that they conform to the provisions of 5.4.2.4.6.2. The bulkheads between the cargo tanks may be fitted with penetrations provided that the loading and unloading pipes are fitted with shut-off devices in the cargo tank from which they come. These pipes are to be fitted at least 0.60 [m] above the bottom. The shut-off devices are to be operable from the deck.

5.4.3.1.12 Double hull spaces and double bottoms in the cargo area are to be arranged for being filled with ballast water only. Double bottoms may, however, be used as fuel oil tanks, provided they comply with 5.4.2.8.

5.4.3.1.13 A cofferdam, the centre part of a cofferdam or another space below deck in the cargo area may be arranged as a service space, provided the bulkheads bounding the service space extend vertically to the bottom. This service space is only to be accessible from the deck.

5.4.3.1.14 The service space is to be watertight with the exception of its access hatches and ventilation inlets.

5.4.3.1.15 Where independent cargo tanks are used, or for double-hull construction where the cargo tanks are integrated in the vessel’s structure, the space between the wall of the vessel and wall of the cargo tanks is to be not less than 0.6 [m]. The space between the bottom of the vessel and the bottom of the cargo tanks is not to be less than 0.5 [m]. The space may be reduced to 0.4 [m] under the pump sumps. The vertical space between the suction well of a cargo tank and the bottom structures is to be not less than 0.1 [m]. When a hull is constructed in the cargo area as a double hull with independent cargo tanks located in hold spaces, the above values are applicable to the double hull. If in this case the minimum values for the inspections of independent tanks referred to in **Error! Reference ource not found.** are not feasible, it must be possible to remove the cargo tanks easily for inspection.

5.4.3.1.16 Where service spaces are located in the cargo area under deck, they are to be arranged so as to be easily accessible and to permit persons wearing protective clothing and breathing apparatus to safely operate the service equipment contained therein. They are to be designed so as to allow injured or unconscious personnel to be removed from such spaces without difficulty, if necessary by means of fixed equipment.

5.4.3.1.17 Cofferdams, double-hull spaces, double bottoms, cargo tanks, hold spaces and other accessible spaces within the cargo area are to be arranged so that they may be completely inspected and cleaned. The dimensions of openings except for those of double hull spaces and double bottoms which do not have a wall adjoining the cargo tanks are to be sufficient to allow a person wearing breathing apparatus to enter or leave the space without difficulties. These openings are to have a minimum cross-sectional

area of 0.36 [$m^2$] and a minimum side length of 0.50 [m]. They are to be designed so as to allow an injured or unconscious person to be removed from the bottom of such a space without difficulties, if necessary by means of fixed equipment. In these spaces the distance between the reinforcements is not to be less than 0.50 [m]. In double bottoms this distance may be reduced to 0.45 [m]. Cargo tanks may have circular openings with a diameter of not less than 0.68 [m].

5.4.3.2 Cargo tank opening

5.4.3.2.1 Cargo tank openings are to be located on deck in the cargo area.

5.4.3.2.2 Cargo tank openings with a cross-section of more than 0.1 [$m^2$] and openings of safety devices for preventing overpressures are to be located not less than 0.5 [m] above deck.

5.4.3.2.3 Each cargo tank or group of cargo tanks connected to a common venting piping is to be fitted with safety devices for preventing unacceptable overpressures or vacuums. These safety devices are to be as follows

5.4.3.2.3.1 For Type N Open vessels

- Safety devices designed to prevent any accumulation of water and its penetration into the cargo tanks;

5.4.3.2.3.2 For Type N Open with flame arrestors

- Safety equipment fitted with flame arrestors capable of withstanding steady burning and designed to prevent any accumulations of water and its penetration into the cargo tanks.

5.4.3.2.3.3 For Type N closed

- Safety devices for preventing unacceptable overpressure or vacuum. Where anti-explosion protection is required in column (17) of Table C of Chapter 3.2 of ADN, the vacuum is to be fitted with a flame arrestors capable of withstanding a deflagration and the pressure relief valve with a high-velocity vent valve acting as a flame arrester capable of withstanding steady burning. Gases are to be discharged upwards. The opening pressure of the high-velocity vent valves and the opening pressure of the vacuum valve is to be permanently marked on the valves.;
- A connection for the safe return ashore of gases expelled during loading;
- A device for depressurization of the tanks. When the list of substances on the vessel contains substances for which protection against explosion is required in column (17) of Table C of Chapter 3.2 of ADN, this device is to include at least a fire-resistant flame arrester and a stop valve which clearly indicates whether it is open or shut.

5.4.3.2.4 Additional requirements for Type N closed

5.4.3.2.4.1 Cargo tanks openings are to be fitted with gastight closures capable of withstanding the test pressure in accordance with 5.4.10.1.3 .

5.4.3.2.4.2 The outlets of high-velocity vent valves are to be located not less than 2 [m] above the deck and at a distance of not less than 6 [m] from the accommodation and from the service spaces outside the cargo area. This height may be reduced when

within a radius of 1 [m] round the outlet of the high-velocity vent valve, there is no equipment, no work is being carried out and signs indicate the area. The setting of the high-velocity vent valves is to be such that during the transport operation they do not blow off until the maximum permissible working pressure of the cargo tanks is reached.

5.4.3.2.4.3 One of the following are to be complied with:

A. Insofar as anti-explosion protection is prescribed in column (17) of Table C of Chapter 3.2 of ADN, venting piping connecting two or more cargo tanks are to be fitted, at the connection to each cargo tank, with a flame arrester with a fixed or spring-loaded plate stack, capable of withstanding detonation. This equipment may consist of:

   a) A flame arrester fitted with a fixed plate stack, where each cargo tank is fitted with a vacuum valve capable of withstanding a deflagration and a high-velocity vent valve of withstanding steady burning;

   b) A flame arrester fitted with a spring-loaded plate stack, where each cargo tank is fitted with a vacuum valve capable of withstanding a deflagration;

   c) A flame arrester with a fixed or spring-loaded plate stack

   d) A flame arrester with a fixed plate stack, where the pressure measurement device is fitted with an alarm system in accordance with 5.4.5.9.2 to 5.4.5.9.5;

   e) A flame arrester with a spring-loaded plate stack, where the pressure measurement device is fitted with an alarm system in accordance with 5.4.5.9.2 to 5.4.5.9.5.

   Only substance which do not mix and which do not react dangerously with each other may be carried simultaneously in cargo tanks connected to a common venting piping. Or,

B. Insofar as anti-explosion protection is prescribed in column (17) of Table C of Chapter 3.2 of ADN, venting piping connecting two or more cargo tanks are to be fitted, at the connection to each cargo tank, with a pressure/vacuum valve incorporating a flame arrester capable of withstanding a detonation/deflagration so that any gas releases is removed by the venting piping. Only substances which do not mix and which do not react dangerously with each other may be carried simultaneously in cargo tanks connected to a common venting piping; Or,

C. Insofar as anti-explosion protection is prescribed in column (17) of Table C of Chapter 3.2 of ADN, venting piping connecting two or more cargo tanks are to be fitted, at the connection to each cargo tank, fitted with a vacuum valve incorporating a flame arrester capable of withstanding a deflagration and a high-velocity vent valve incorporating a flame arrester capable of withstanding steady burning. Several different substances may be carried simultaneously. Or,

D. Insofar as anti-explosion protection is prescribed in column (17) of Table C of Chapter 3.2 of ADN, venting piping connecting two or more cargo tanks are to be fitted, at the connection to each cargo tank, with a shut-off device capable

of withstanding a detonation, where each cargo tank is fitted with a vacuum valve capable of withstanding a deflagration and a high-velocity vent valve capable of withstanding steady burning. Only substances which do not mix and which do not react dangerously with each other may be carried simultaneously in cargo tanks connected to a common venting piping.

5.4.3.2.5 Additional requirements for Type N closed and Type N open with flame arrester

5.4.3.2.5.1 Closures which are normally used during loading or unloading operations are not to cause sparling when operated.

5.4.4 Stability

5.4.4.1 General

5.4.4.1.1 Proof of sufficient stability is to be submitted.

5.4.4.1.2 The basic value for the stability calculation, the vessel's lightweight and location of centre of gravity, is to be determined wither by means of an inclining experiment or by detailed mass and moment calculation. In latter case the light weight of the vessel is to be checked by means of a light weight test with a tolerance limit of ±5% between the mass determined by calculation and the displacement determined by the draught readings.

5.4.4.1.3 Proof of sufficient intact stability is to be submitted for all stages of loading and unloading and for the final loading condition for all the relative densities of the substances transported contained in the list of cargoes. For every loading operation, taking account of the actual fillings and floating position of cargo tanks, ballast tanks and compartment, drinking water and sewage tanks and tanks containing products for the operation of the vessel, the vessel is to comply with the intact and damage stability requirements. Intermediate stages during operations are also to be taken into consideration. The proof of sufficient stability is to be shown for every operating, loading and ballast condition in the stability booklet, to be approved. If it is unpractical to pre-calculate the operating, loading and ballast conditions, an approved loading instrument is to be installed and used which contains the contents of the stability booklet.

5.4.4.1.4 Floatability after damage is to be proved for the most unfavorable loading condition. For this purpose, calculated proof of sufficient stability is to be established for critical intermediate stages of flooding and for the final stage of flooding.

5.4.4.2 Intact Stability

5.4.4.2.1 For vessels with independent cargo tanks and for double-hull constructions with cargo tanks integrated in the frames of the vessel, the requirements for intact stability resulting from the damage stability calculation is to be fully complied with.

5.4.4.2.2 For vessels with cargo tanks of more than 0.7B in width, proof is to be submitted that the following stability requirements have been complied with:

a) In the positive area of the righting lever curve up to immersion of the first non-watertight opening, righting lever(GZ) is not to be less than 0.1 [m]

b) The surface of the positive area of the righting lever curve up to immersion of the first non-watertight opening and in any event up to an angle of heel $\leq 27^\circ$ is not to be less than 0.024 [m rad]

c) The metacentric height (GM) should not be less than 0.1 [m]

This condition are to be meet bearing in mind the influence of all free surface in tanks for all stages of loading and unloading.

5.4.4.3 Damage Stability

5.4.4.3.1 For vessels with independent cargo tanks and for double hull constructions with cargo tanks integrated in the frames of the vessel, the following assumptions are to be taken into consideration for the damaged condition.

a) extent of side damage:

| | |
|---|---|
| a) Longitudinal extent : | b) At least 0.10 $L_{OA}$, but not less than 5 [m] |
| c) Transverse extent: | d) 0.59 [m] inboard from the vessel's side at right angles to the centerline at the level corresponding to the maximum draught , or when applicable, the distance allowed by 5.4.3.1.2, reduced by 0.01[m] |
| e) Vertical extent : | f) From the base line upwards without limit |

b) extent of bottom damage:

| | |
|---|---|
| g) Longitudinal extent: | h) At least 0.10 $L_{OA}$, but not less than 5 [m] |
| i) Transverse extent: | j) 3 [m] |
| j) Vertical extent: | k) From the base 0.49[m] upwards, the sump excepted |

c) Any bulkhead within the damaged area is to be assumed damaged, which means that the location of bulkheads is to be chosen to ensure that the vessel remains afloat after the flooding of two or more adjacent compartments in the longitudinal direction.

The following provisions are applicable:

- For bottom damage, adjacent athwartship compartments are also to be assumed flooded
- the lower edge of any non-watertight opening (e.g. windows, doors and access hatchways), at the final stage of flooding, is to be not less than 0.10 [m] above the damage waterline.
- In general, permeability is to be assumed to be 95%. Where an average permeability of less than 95% is calculated for any compartment, this calculated value obtained may be used. However, minimum values of permeability, μ, given in
- are to be used. For the main engine room, only the one-compartment standard need be taken into account, i.e. the end bulkheads of the engine room are to be assumed as not damaged.

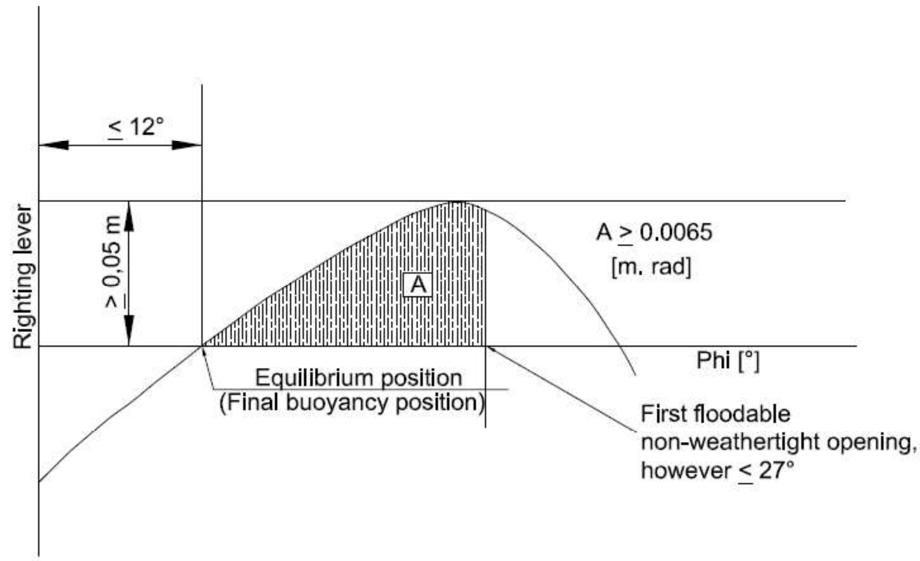
| **Table 3: Permeability** | |
|---|---|
| Engine Room | 85% |
| Accommodation | 95% |
| Double Bottom, Oil Fuel Tanks, Ballast Tanks, etc. depending on whether, according to their function, they have to be assumed as full or empty for vessel floating at the maximum permissible draft | 0% or 95% |

5.4.4.3.2 For the intermediate stage of flooding the following criteria have to be fulfilled:

- GZ≥0.03[m]
- Range of positive GZ: 5°

5.4.4.3.3 At the stage of equilibrium (in the final stage of flooding), the angle of heel is not to exceed 12°. Non-watertight openings are not to be flooded before reaching the stage of equilibrium. If such openings are immersed before the stage of equilibrium, the corresponding spaces are to be considered flooded for the purpose of stability calculation.

5.4.4.3.4 The positive range of the righting lever curve beyond the stage of equilibrium is to have a righting lever of ≥ 0.05 [m] in association with an area under the curve of ≥ 0.0065 [m.rad]. The minimum values of stability are to be satisfied up to immersion of the first non-weathertight openings and in any event up to an angle of heel ≤ 27°. If nonwatertight openings are immersed before that stage, the corresponding spaces are to be considered flooded for the purpose of stability calculation.




5.4.4.3.5 If openings through which undamaged compartments may additionally become flooded are capable of being closed watertight, the closing appliances are to be marked accordingly.

5.4.4.3.6 Where cross- or down-flooding openings are provided for reduction of unsymmetrical flooding, the time of equalization is not to exceed 15 min, provided during the intermediate stages of flooding sufficient stability has been proved.

5.4.5 Safety and Control Installations

5.4.5.1 Cargo tanks are to be provided with the following equipment:

a) a mark inside the tank indicating the liquid level of 97%

b) a level gauge

c) a level alarm device which is activated at the latest when a degree of filling of 90% is reached

d) a high level sensor for actuating the facility against overflowing when a degree of filling of 97.5% is reached

e) for Type N closed, an instrument for measuring the pressure of the vapour phase inside the cargo tank

f) an instrument for measuring the temperature of the cargo if in column (9) of Table C of Chapter 3.2 of ADN a heating installation is required or if in column (20) a possibility of heating the cargo is required or if a maximum temperature is indicated.

g) a connection for a closed-type or partly closed-type sampling device, and/or at least one sampling opening as required in column (13) of Table C of Chapter 3.2 of ADN.

5.4.5.2 When the degree of filling in percent is determined, an error of not more than 0.5% is permitted. It is to be calculated on the basis of

the total cargo tank capacity including the expansion trunk.

5.4.5.3 The level gauge is to allow readings from the control position of the shut-off devices of the particular cargo tank. The permissible maximum filling level of 95% and 97%, as given in list of substances is to be marked on each level gauge. Permanent reading of the overpressure and vacuum is to be possible from a location from which loading or unloading operations may be interrupted. The permissible maximum overpressure and vacuum is to be marked on each level gauge. Readings are to be possible in all weather conditions.

5.4.5.4 The level alarm device is to give a visual and audible warning on board when actuated. The level alarm device is to be independent of the level gauge.

5.4.5.5 The visual and audible signals given by the level alarm device are to be clearly distinguishable from those of the high level sensor. The visual alarm is to be visible at each control position on deck of the cargo tank stop valves. It is to be possible to easily check the functioning of the sensors and electric circuits or these are to be “intrinsically safe apparatus”.

5.4.5.6 When the control elements of the shut-off devices of the cargo tanks are located in a control room, it is to be possible to stop the loading pumps and read the level gauges in the control room, and the visual and audible warning given by the level alarm device, the high level sensor referred to in 5.4.5.1 d) and the instruments for measuring the pressure and temperature of the cargo is to be noticeable in the control room and on deck.

5.4.5.7 When refrigerated substances are carried the opening pressure of the safety system is to be determined by the design of the cargo tanks. In the event of the transport of substances that must be carried in a refrigerated state the opening pressure of the safety system is not to be less than 25 [kPa] greater than the maximum pressure calculated according to 5.4.6.2.

5.4.5.8 High Level Sensor

5.4.5.8.1 The high level sensor referred in 5.4.5.1 d) above is to give a visual and audible alarm on board and at the same time actuate an electrical contact which in the form of a binary signal interrupts the electric current loop provided and fed by the shore facility against overflowing during loading operations. The signal is to be transmitted to the shore facility via a watertight two-pin lug of a connecter device in accordance with IEC 60309 for direct current of 40 to 50 volts, identification color white, position of the nose 10 h. The plug is to be permanently fitted to the vessel close to the shore connections of the loading and unloading piping.

5.4.5.8.2 The high level sensor is also to be capable of switching off the vessel’s own discharging pump.

5.4.5.8.3 The high level sensor is to be independent of the level alarm device, but it may be connected to the level gauge.

5.4.5.8.4 During discharging by means of the on-board pump, it is to be possible for the shore facility to switch it off. For this purpose, an independent intrinsically safe power line, fed by the vessel, is to be switched off by the shore facility by means of an electrical contact. It is to be possible for the binary signal of the shore facility to be transmitted via a watertight two-pole socket or a connecter device in accordance with IEC 60309 for direct current of 40 to 50 volts, identification color white, position of the nose 10 h. This socket is to be permanently fitted to the vessel close to the shore connections of the unloading piping.

5.4.5.9 Cargo tank pressure and temperature monitoring

5.4.5.9.1 Following requirements are applicable to Type N closed

5.4.5.9.2 When the pressure or temperature exceeds a set value, instruments for measuring the vacuum or overpressure of the gaseous phase in the cargo tank or the temperature of the cargo is to activate a visual and audible alarm in the wheelhouse. When the wheelhouse is unoccupied the alarm also is also to be audible in a location occupied by a crew member.

5.4.5.9.3 When the pressure exceeds the set value during loading and unloading, the instrument for measuring the pressure by means of the plug referred to in **Error! eference source not found.**, is to

initiate simultaneously an electrical contact which is to put into effect measures to interrupt the loading and unloading operation. If the vessel's own discharge pump is used, it is to be switched off automatically.

5.4.5.9.4 The instrument for measuring the overpressure or vacuum is to activate the alarm at latest when an overpressure equal to 1.15 times the opening pressure of the pressure relief device, or a vacuum pressure equal to the construction vacuum pressure but not exceeding 5 [kPa]. The maximum allowable temperature is indicated in column (20) of Table C of ADN Chapter 3.2 of ADN. The sensors for these alarms may be connected to the alarm device of the sensor.

5.4.5.9.5 When it is prescribed in column (20) of Table C of ADN Chapter 3.2 of ADN, the instrument for measuring the overpressure of the gaseous phase is to activate a visible and audible alarm in the wheelhouse when the overpressure exceeds 40 [kPa] during the voyage. When the wheelhouse is unoccupied, the alarm is also to be audible in a location occupied by a crew member. It is to be possible to read the gauges in direct proximity to the control for the water spray system.

5.4.6 Cargo pressure and temperature Control

5.4.6.1 Requirements for maintenance of cargo pressure and temperature

5.4.6.1.1 Unless the entire cargo system is designed to resist the full effective vapour pressure of the cargo at the upper limits of the ambient design temperatures, the pressure of the tanks is to be kept below the permissible maximum set pressure of the safety valves, by one or more of the following means:

a) A system for the regulation of cargo tank pressure using mechanical refrigeration.

b) A system ensuring safety in the event of the heating or increase in pressure of the cargo. The insulation or the design pressure of the cargo tank, or the combination of these two elements, is to be such as to leave an adequate margin for the operating period and the temperatures expected; in each case the system is to be deemed acceptable by Designated Authority/Classification Society and is to ensure safety for a minimum time of three times the operation period;

5.4.6.1.2 The systems prescribed above are to be constructed, installed and tested to the satisfaction of Designated Authority/Classification Society. The materials used in their construction is to be compatible with the cargoes to be carried. For normal service, the upper ambient design temperature limits are to be:

Air: +45° C

Water : +32° C

5.4.6.1.3 The cargo storage system is to be capable of resisting the full vapour pressure of the cargo at upper limits of the ambient design temperatures, whatever the system adopted to deal with the boil-off gas. This requirement is indicated by remark 37 in column (20) of Table C of Chapter 3.2 of ADN.

5.4.6.2 Refrigeration system

5.4.6.2.1 The refrigeration system referred to in 5.4.6.1.1 a) is to be composed of one or more units capable of keeping the pressure and temperature of the cargo at the upper limits of the ambient design temperatures at the prescribed level. Unless another means of regulating cargo pressure and temperature deemed satisfactory by Designated Authority/Classification Society is provided, provision is to be made for one or more stand-by units with an output at least equal to that of the largest prescribed unit. A stand-by unit is to include a compressor, its engine, its control system and all necessary accessories to enable it to operate independently of the units normally used. Provision is to be made for a stand-by heat-exchanger unless the system's normal heat-exchanger has a surplus capacity equal to at least 25% of the largest prescribed capacity. It is not

necessary to make provision for separate piping. Cargo tanks, piping and accessories are to be insulated so that, in the event of a failure of all cargo refrigeration systems, the entire cargo remains for at least 52 hours in a condition not causing the safety valves to open.

5.4.6.2.2 The security devices and the connecting lines from the refrigeration system are to be connected to the cargo tanks above the liquid phase of the cargo when the tanks are filled to their maximum permissible degree of filling. They are to remain within the gaseous phase, even if the vessel has a list up to 12 degrees.

5.4.6.2.3 When several refrigerated cargoes with a potentially dangerous chemical reaction are carried simultaneously, particular care is to be given to the refrigeration systems so as to prevent any mixing of the cargoes. For the carriage of such cargoes, separate refrigeration systems, each including the full stand-by unit referred to in **Error! Reference ource not found.**, is to be provided for each cargo. When, however, refrigeration is ensured by an indirect or combined system and no leak in the heat exchangers can under any foreseeable circumstances lead to the mixing of cargoes, no provision need be made for separate refrigeration units for the different cargoes.

5.4.6.2.4 When several refrigerated cargoes are not soluble in each other under conditions of carriage such that their vapour pressures are added together in the event of mixing, particular care is to be given to the refrigeration systems to prevent any mixing of the cargoes.

5.4.6.2.5 When the refrigeration systems require water for cooling, a sufficient quantity is to be supplied by a pump or pumps used exclusively for the purpose. This pump or pumps are to have at least two suction pipes, leading from two water intakes, one to port, the other to starboard. Provision is to be made for a stand-by pump with a satisfactory flow; this may be a pump used for other purposes provided that its use for supplying water for cooling does not impair any other essential service.

5.4.6.2.6 The refrigeration system may take one of the following forms:

a) Direct system: the cargo vapours are compressed, condensed and returned to the cargo tanks. This system is not to be used for certain cargoes specified in Table C of Chapter 3.2 of ADN. This requirement is indicated by remark 35 in column (20) of Table C of Chapter 3.2 of ADN;

b) Indirect system: the cargo or the cargo vapours are cooled or condensed by means of a coolant without being compressed;

c) Combined system: the cargo vapours are compressed and condensed in a cargo/coolant heat-exchanger and returned to the cargo tanks. This system is not to be used for certain cargoes specified in Table C of Chapter 3.2 of ADN. This requirement is indicated by remark 36 in column (20) of Table C of Chapter 3.2 of ADN.

5.4.6.2.7 All primary and secondary coolant fluids are to be compatible with each other and with the cargo with which they may come into contact. Heat exchange may take place either at a distance from the cargo tank, or by using cooling coils attached to the inside or the outside of the cargo tank.

5.4.6.2.8 When the refrigeration system is installed in a separate service space, this service space is to meet the requirements of 5.4.2.4.6.2.

5.4.6.2.9 For all cargo systems, the heat transmission coefficient as used for the determination of the holding time is to be determined by calculation. Upon completion of the vessel, the correctness of the calculation is to be checked by

means of a heat balance test. The calculation and test is to be performed under supervision by Designated Authority/Classification Society. The heat transmission coefficient is to be documented and kept on board. The heat transmission coefficient is to be verified at every renewal of the certificate of approval.

5.4.6.3 Cargo heating system

5.4.6.3.1 Boilers which are used for heating the cargo are to be fuelled with a liquid fuel having a flashpoint of more than 55 °C. They are to be placed either in the engine room or in another separate space below deck and outside the cargo area, which is accessible from the deck or from the engine room.

5.4.6.3.2 The cargo heating system is to be designed so that the cargo cannot penetrate into the boiler in the case of a leak in the heating coils. A cargo heating system with artificial draught is to be ignited electrically.

5.4.6.3.3 The ventilation system of the engine room is to be designed taking into account the air required for the boiler.

5.4.6.3.4 Where the cargo heating system is used during loading, unloading or gas-freeing, the service space which contains this system is to fully comply with the requirements of 5.4.9.3.7.1. This requirement does not apply to the inlets of the ventilation system. These inlets are to be located at a minimum distance of 2 [m] from the cargo area and 6 [m] from the openings of cargo tanks or residual cargo tanks, loading pumps situated on deck, openings of high velocity vent valves, pressure relief devices and shore connections of loading and unloading piping and must be located not less than 2 m above the deck. The requirements of 5.4.9.3.7.1 are not applicable to the unloading of substances having a flashpoint of 60 °C or more when the temperature of the product is at least 15 K lower at the flashpoint.

5.4.6.4 Water spray system

5.4.6.4.1 When water-spraying is required in column (9) of Table C of Chapter 3.2 of ADN, a water-spray system is to be installed in the cargo area on deck for the purpose of cooling the tops of cargo tanks by spraying water over the whole surface so as to avoid safely the activation of the high-velocity vent valve at 10 [kPa] or as regulated.

5.4.6.4.2 The spray nozzles are to be so installed that the entire cargo deck area is covered and the gases released are precipitated safely. The system is to be capable of being put into operation from the wheelhouse and from the deck. Its capacity is to be such that when all the spray nozzles are in operation, the outflow is not less than 50 litres per square metre of deck area and per hour.

5.4.7 Pumps and piping

5.4.7.1 Cargo pumps are to be capable of being shut down from the cargo area and from a position outside cargo area.

5.4.7.2 Piping for loading and unloading is to be independent of any other piping of the vessel.

5.4.7.3 The piping for loading and unloading is to be arranged so that, after loading or unloading operations, the liquid remaining in these pipes may be safely removed and may flow either into the vessel's cargo tanks or the tanks ashore;

5.4.7.4 Piping for loading and unloading is to be clearly distinguishable from other piping.

5.4.7.5 Each shore connection of the venting piping and shore connections of the piping for loading and unloading, through which the loading or unloading operation is carried out, is to be fitted with a shut-off device. However, each shore connection is to be fitted with a blind flange when it is not in operation.

5.4.7.6 Piping for loading and unloading and venting piping, is not to have flexible connections fitted with sliding seals.

5.4.7.7 The stop valves or other shut-off devices of the piping for loading and unloading are to indicate whether they are open or shut.

5.4.7.8 The piping for loading and unloading is to have, at the test pressure, the required elasticity, leakproofness and resistance to pressure.

5.4.7.9 The piping for loading and unloading is to be fitted with pressure gauges at the outlet of the pumps. The permissible maximum

overpressure or vacuum is to be indicated on each measuring device. Readings are to be possible in all weather conditions.

5.4.7.10 When piping for loading and unloading are used for supplying the cargo tanks with washing or ballast water, the suctions of these pipes are to be located within the cargo area but outside the cargo tanks. Pumps for tank washing systems with associated connections may be located outside the cargo area, provided the discharge side of the system is arranged in such a way that the suction is not possible through that part. A spring-loaded non-return valve is to be provided to prevent any gases from being expelled from the cargo area through the tank washing system.

5.4.7.11 A non-return valve is to be fitted at the junction between the water suction pipe and the cargo loading pipe.

5.4.7.12 The permissible loading and unloading flows are to be calculated. Calculations concern the permissible maximum loading and unloading flow for each cargo tank or each group of cargo tanks, taking into account the design of the ventilation system. These calculations are to take into consideration the fact that in the event of an unforeseen cut-off of the vapour return piping of the shore facility, the safety devices of the cargo tanks will prevent pressure in the cargo tanks from exceeding the following values:

- over-pressure: 115% of the opening pressure of the high-velocity vent valve;
- vacuum pressure: not more than the construction vacuum pressure but not exceeding 5 [kPa] (0.05 bar).

The main factors to be considered are the following:

a) Dimensions of the ventilation system of the cargo tanks

b) Gas formation during loading: multiply the largest loading flow by a factor of not less than 1.25

c) Density of the vapour mixture of the cargo based on 50% volume vapour of 50% volume air;

d) Loss of pressure through ventilation pipes, valves and fittings. Account will be taken of a 30% clogging of the mesh of the flame-arrester;

e) Clocking pressure of the safety valves

The permissible maximum loading and unloading flows for each cargo tank or for each group of cargo tanks is to be given in an on-board instruction.

5.4.7.13 Compressed air generated outside the cargo area or wheelhouse can be used in the cargo area subject to the installation of a spring-loaded non-return valve to ensure that no gases can escape from the cargo area through the compressed air system into accommodation or service spaces outside the cargo area.

5.4.7.14 If the vessel is carrying several dangerous substances liable to react dangerously with each other, a separate pump with its own piping for loading and unloading is to be installed for each substance. The piping is not to pass through a cargo tank containing dangerous substances with which the substance in question is liable to react.

5.4.7.15 Additional requirements for Type N open vessel carrying substances having corrosive properties, Type Closed and Type N open with flame arrester

5.4.7.15.1 Pumps and accessory loading and unloading piping is to be located in the cargo area

5.4.7.15.2 Cargo pumps situated on deck are to be located not less than 6 [m] from entrances to or openings of, the accommodation and service spaces outside the cargo area.

5.4.7.15.3 No cargo piping is to be located below deck, except those inside the cargo tanks and inside the cargo pump-room;

5.4.7.15.4 The shore connections are to be located not less than 6 [m] from the entrances to, or openings of, the accommodation and services spaces outside the cargo area.

5.4.7.15.5 The distance referred to in 5.4.7.15.2 and 5.4.7.15.4 may be reduced to 3[m] if a transverse bulkhead complying with 5.4.2.2.2 is situated at the end of the cargo area. The openings are to be provided with doors. The following notice is to be displayed on the doors:

**"DO NOT OPEN DURING LOADING AND UNLOADING WITHOUT PERMISSION.**

**CLOSE IMMEDIATELY."**

5.4.7.15.6 Every compartment of the piping for loading and unloading

is to be electrically connected to the hull.

5.4.7.16 Additional requirements for Type Closed and Type N open with flame arrester

5.4.7.16.1 The piping for loading is to extent down to the bottom of the cargo tanks.

5.4.8 Receptacles for residual products and receptacles for slops

5.4.8.1 If vessels are provided with a tank for residual products, it is to comply with the provisions of 5.4.8.3 , 5.4.8.4 to 5.4.8.7. Receptacles for residual products and receptacles for slops are to be located only in the cargo area. During the filling of the receptacles for residual products, means for collecting any leakage are to be placed under the filling connections.

5.4.8.2 Receptacles for slops are to be fire resistant and are to be capable of being closed with lids. The receptacles for slops are to be marked and be easy to handle.

5.4.8.3 The maximum capacity of a tank for residual products is 30 [$m^3$].

5.4.8.4 The tank for residual products is to be equipped with:

5.4.8.4.1 in the case of open system:

- A device for ensuring pressure equilibrium;
- An ullage opening
- Connections, with slop valves, for pipes and hose assemblies;

5.4.8.4.2 in the case of a protected system:

- A device for ensuring pressure equilibrium, fitted with a flame-arrester capable of withstanding steady burning;
- An ullage opening;
- Connections, with stop valves, for pipes and hose assemblies;

5.4.8.4.3 in case of a closed system:

- A vacuum valve and high-velocity vent valve.

  The high velocity vent valve is to be so regulated as not to open during carriage. This condition is met when the opening pressure of the valve meets the conditions set out in column (10) of Table C of Chapter 3.2 of ADN; When anti-explosion protection is required in column (17) of Table C of Chapter 3.2 of ADN, the vacuum-relief valve is to be capable of withstanding deflagrations and the high velocity vent valve is to withstand steady burning;

5.4.8.4.4 a device for measuring the degree of filling;

5.4.8.4.5 connections, with stop valves, for pipes and hose assemblies

5.4.8.5 Receptacles for residual products are to be equipped with:

- a connection enabling gases released during filling to be evacuated safely;
- a possibility of indicating the degree of filling;
- connections with shut-off devices, for pipes and hose assemblies.

5.4.8.6 Receptacles for residual products are to be connected to the venting piping of cargo tanks only for the time necessary to fill them. During the filling of the receptacle, released gases are to be safely evacuated.

5.4.8.7 Receptacles for residual products and receptacles for slops placed on the deck are to be located at a minimum distance from the hull equal to one quarter of the vessel's breadth.

5.4.9 Requirements for Electrical Installations

5.4.9.1 Documents concerning electrical installations

5.4.9.1.1 In addition to the other required documentations, the following documents are to be on board:

a) a drawing indicating the boundaries of the cargo area and the location of the electrical equipment installed in this area;

b) a list of the electrical equipment referred to in (a) above including the following particulars: machine or appliance, location, type of protection, type of protection against explosion, testing body and approval number;

c) a list of or general plan indicating the electrical equipment outside the cargo

area which may be operated during loading, unloading or gas-freeing. All other electrical equipment is to be marked in red. See 5.4.9.3.7.1 and 5.4.9.3.8.

5.4.9.2 Electrical installations

5.4.9.2.1 Only distribution systems without return connection to the hull are permitted.

This provision does not apply to:

- active cathodic corrosion protection;
- certain limited sections of the installations situated outside the cargo area (e.g. connections of starters of diesel engines);
- the device for checking the insulation level referred to in 5.4.9.2.2 below.

5.4.9.2.2 Every insulated distribution network is to be fitted with an automatic device with a visual and audible alarm for checking the insulation level.

5.4.9.2.3 For the selection of electrical equipment to be used in zones presenting an explosion risk, the explosion groups and temperature classes assigned to the substances carried in accordance with columns (15) and (16) of Table C of Chapter 3.2 of ADN is to be taken into consideration.

5.4.9.3 Type and location of electrical equipment

5.4.9.3.1 Only the following equipment may be installed in cargo tanks, residual cargo tanks, and piping for loading and unloading (comparable to zone 0):

- measuring, regulation and alarm devices of the EEx (ia) type of protection.

5.4.9.3.2 Only the following equipment may be installed in the cofferdams, double-hull spaces, double bottoms and hold spaces (comparable to zone 1):

- measuring, regulation and alarm devices of the certified safe type;
- lighting appliances of the "flame-proof enclosure" or "apparatus protected by pressurization" type of protection;
- hermetically sealed echo sounding devices the cables of which are led through thick-walled steel tubes with gastight connections up to the main deck;
- cables for the active cathodic protection of the shell plating in protective steel tubes such as those provided for echo sounding devices.

The following equipment may be installed only in double-hull spaces and double bottoms if used for ballasting:

- Permanently fixed submerged pumps with temperature monitoring, of the certified safe type.

5.4.9.3.3 Only the following equipment may be installed in the service spaces in the cargo area below deck (comparable to zone 1):

- measuring, regulation and alarm devices of the certified safe type;
- lighting appliances of the "flame-proof enclosure" or "apparatus protected by pressurization" type of protection;
- motors driving essential equipment such as ballast pumps with temperature monitoring; they are to be of the certified safe type.

5.4.9.3.4 The control and protective equipment of the electrical equipment referred to in paragraphs 5.4.9.3.1,5.4.9.3.2 and 5.4.9.3.3 above is to be located outside the cargo area if they are not intrinsically safe.

5.4.9.3.5 The electrical equipment in the cargo area on deck (comparable to zone 1) are to be of the certified safe type.

5.4.9.3.6 Accumulators are to be located outside the cargo area.

5.4.9.3.7 Electrical equipment used during loading, unloading and gas-

freeing during berthing and which are located outside the cargo area are to (comparable to zone 2) be at least of the "limited explosion risk" type.

5.4.9.3.7.1 This provision does not apply to:

a) lighting installations in the accommodation, except for switches near entrances to accommodation;

b) radiotelephone installations in the accommodation or the wheelhouse;

c) mobile and fixed telephone installations in the accommodation or the wheelhouse;

d) electrical installations in the accommodation, the wheelhouse or the service spaces outside the cargo areas if:

A. These spaces are fitted with a ventilation system ensuring an overpressure of 0.1 [kPa] (0.001 bar) and none of the windows is capable of being opened; the air intakes of the ventilation system are to be located as far away as possible, however, not less than 6 [m] from the cargo area and not less than 2 [m] above the deck;

B. The spaces are fitted with a gas detection system with sensors:

i. at the suction inlets of the ventilation system;

ii. directly at the top edge of the sill of the entrance doors of the accommodation and service spaces;

C. The gas concentration measurement is continuous;

D. When the gas concentration reaches 20% of the lower explosive limit, the ventilators are switched off. In such a case and when the overpressure is not maintained or in the event of failure of the gas detection system, the electrical installations which do not comply with 5.4.9.3.7 above, are to be switched off. These operations are to be performed immediately and automatically and

activate the emergency lighting in the accommodation, the wheelhouse and the service spaces, which is to comply at least with the "limited explosion risk" type. The switching-off is to be indicated in the accommodation and wheelhouse by visual and audible signals;

E. The ventilation system, the gas detection system and the alarm of the switch-off device fully comply with the requirements of 5.4.9.3.7 above;

F. The automatic switch-off device is set so that no automatic switching-off may occur while the vessel is under way.

e) Inland AIS (automatic identification systems) stations in the accommodation and in the wheelhouse if no part of an aerial for electronic apparatus is situated above the cargo area and if no part of a VHF antenna for AIS stations is situated within 2 [m] from the cargo area.

5.4.9.3.8 The electrical equipment which does not meet the requirements set out in 5.4.9.3.7.1 above together with its switches are to be marked in red. The disconnection of such equipment is to be operated from a centralised location on board.

5.4.9.3.9 An electric generator which is permanently driven by an engine and which does not meet the requirements of 5.4.9.3.7.1 above, is to be fitted with a switch capable of shutting down the excitation of the generator. A notice board with the operating instructions is to be displayed near the switch.

5.4.9.3.10 Sockets for the connection of signal lights and gangway lighting are to be permanently fitted to the vessel close to the signal mast or the gangway. Connecting and disconnecting is not to be possible except when the sockets are not live.

5.4.9.3.11 The failure of the power supply for the safety and control equipment is to be immediately indicated by visual and audible signals at the locations where the alarms are usually actuated.

5.4.9.4 Earthing

5.4.9.4.1 The metal parts of electrical appliances in the cargo area which are not live as well as protective metal tubes or metal sheaths of cables in normal service are to be earthed, unless they are so arranged that they are automatically earthed by bonding to the metal structure of the vessel.

5.4.9.4.2 The provisions of 5.4.9.4.1 above apply also to equipment having service voltages of less than 50 [V].

5.4.9.4.3 Independent cargo tanks are to be earthed.

5.4.9.4.4 Receptacles for residual products are to be capable of being earthed.

5.4.9.5 Electrical cables

5.4.9.5.1 All cables in the cargo area are to have a metallic sheath.

5.4.9.5.2 Cables and sockets in the cargo area are to be protected against mechanical damage.

5.4.9.5.3 Movable cables are prohibited in the cargo area, except for intrinsically safe electric circuits or for the supply of signal lights, gangway lighting

5.4.9.5.4 Cables of intrinsically safe circuits are only to be used for such circuits and are to be separated from other cables not intended for being used in such circuits (e.g. they are not to be installed together in the same string of cables and they are not to be fixed by the same cable clamps).

5.4.9.5.5 For movable cables intended for signal lights, gangway lighting, only sheathed cables of type H 07 RN-F in accordance with IEC publication-60 245-4 (1994) or cables of at least equivalent design having conductors with a cross-section of not less than 1.5 [$mm^2$] is

to be used. These cables are to be as short as possible and installed so that damage is not likely to occur.

5.4.9.5.6 The cables required for the electrical equipment referred to in 5.5.9.3.2 and 5.5.9.3.3 are accepted in cofferdams, double-hull spaces, double bottoms, hold spaces and service spaces below deck. When the vessel is only authorized to carry substances for which no antiexplosion protection is required in column (17) of Table C in Chapter 3.2 of ADN, cable penetration is permitted in the hold spaces.

5.4.10 Inspection and Testing

5.4.10.1 Pressure tests

5.4.10.1.1 The cargo tanks, residual cargo tanks, cofferdams, piping of loading and unloading, with the exception of discharge hoses are subjected to initial tests before being put into service and thereafter at prescribed intervals.

5.4.10.1.2 Where a heating system is provided inside the cargo tanks, the heating coils are to be subjected to initial tests before being put into service and thereafter at prescribed intervals

5.4.10.1.3 The test pressure for the cargo tanks and residual cargo tanks is not to be less than 1.3 times the design pressure. The test pressure for the cofferdams and open cargo tanks is to be not less than 10 [kPa] gauge pressure.

5.4.10.1.4 The test pressure for piping for loading and unloading is to be not less than 1000 [kPa] gauge pressure.

5.4.10.1.5 The maximum intervals for the periodic teats is to be 11 years.

**5.5 Requirements for Type C Tankers**

5.5.1 General

5.5.1.1 Application

5.5.1.1.1 Requirements of this subsection are applicable to Type C tankers.

5.5.2 Arrangement

5.5.2.1 Protection against the penetration of gases

5.5.2.1.1 The vessel is to be designed so as to prevent gases from penetrating into the accommodation and the service spaces.

5.5.2.1.2 Outside the cargo area, the lower edges of door-openings in the sidewalls of superstructures and the coamings of access hatches to under-deck spaces are to have a height of not less than 0.50 [m] above the deck. This requirement need not be complied with if the wall of the superstructures facing the cargo area extends from one side of the vessel to the other and has doors the sills of which have a height of not less than 0.50 [m]. The height of this wall is not to be less than 2.00 [m]. In this case, the lower edges of door-openings in the sidewalls of superstructures and of coamings of access hatches behind this wall are to have a height of not less than 0.10 [m]. The sills of engine room doors and the coamings of its access hatches are to, however, always have a height of not less than 0.50 [m].

5.5.2.1.3 In the cargo area, the lower edges of door-openings in the sidewalls of superstructures are to have a height of not less than 0.50 [m] above the deck and the sills of hatches and ventilation openings of premises located under the deck are to have a height of not less than 0.50 [m] above the deck. This requirement does not apply to access openings to double-hull and double bottom spaces.

5.5.2.1.4 The bulwarks, foot-rails, etc. are to be provided with sufficiently large openings which are located directly above the deck.

5.5.2.2 Ventilation

5.5.2.2.1 Each hold space is to have two openings, the dimensions and location of which are to be such as to permit effective ventilation of any part of the hold space. If there are no such openings, it is to be possible to fill the hold spaces with inert gas or dry air.

5.5.2.2.2 Double-hull spaces and double bottoms within the cargo area which are not arranged for being filled with ballast water, hold spaces and cofferdams are to be provided with ventilation systems.

5.5.2.2.3 Any service spaces located in the cargo area below deck are to be provided with a system of forced ventilation with sufficient power for ensuring at least 20 changes of air per hour based on the volume of the space. The ventilation exhaust ducts are to extend down to 50 [mm] above the bottom of the service space. The air is to be supplied through a duct at the top of the service space. The air inlets are to be located not less than 2 [m] above the deck, at a distance of not less than 2 [m] from tank openings and 6 [m] from the outlets of safety valves. The extension pipes, which may be necessary, may be of the hinged type.

5.5.2.2.4 Ventilation of accommodation and service spaces is to be possible.

5.5.2.2.5 Ventilators used in the cargo area are to be designed so that no sparks may be emitted on contact of the impeller blades with the housing and no static electricity may be generated.

5.5.2.2.6 Notice boards are to be fitted at the ventilation inlets indicating the conditions when they are to be closed. Any ventilation inlets of accommodation and service spaces leading outside are to be fitted with fire flaps. Such ventilation inlets are to be located not less than 2 [m] from the cargo area. Ventilation inlets of service spaces in the cargo area may be located within such area.

5.5.2.2.7 The flame-arresters prescribed in 5.5.2.6.4, 5.5.3.2.5, 5.5.3.2.6, 5.5.3.2.7, 5.5.8.4, **Error! eference source not found.**, 5.5.8.6 and 5.5.8.7 are to be type approved.

5.5.2.3 Engine rooms

5.5.2.3.1 Internal combustion engines for the vessel's propulsion as well as internal combustion engines for auxiliary machinery is to be located outside the cargo area. Entrances and other openings of engine rooms are to be at a distance of not less than 2 [m] from the cargo area. The engine rooms are to be accessible from the deck; the entrances are not to face the cargo area.

5.5.2.3.2 Where the doors are not located in a recess whose depth is at least equal to the door width, the hinges are to face the cargo area.

5.5.2.4 Accommodation and service spaces

5.5.2.4.1 Accommodation spaces and the wheelhouse are to be located outside the cargo area forward of the fore vertical plane or abaft the aft vertical plane bounding the part of the cargo area below deck. Windows of the wheelhouse which are located not less than 1 [m] above the bottom of the wheelhouse may tilt forward.

5.5.2.4.2 Entrances to spaces and openings of superstructures are not to face the cargo area. Doors opening outward and not located in a recess the depth of which is at least equal to the width of the doors are to have their hinges face the cargo area.

5.5.2.4.3 Entrances from the deck and openings of spaces facing the weather are to be capable of being closed. The following instruction is to be displayed at the entrance of such spaces:

**DO NOT OPEN DURING LOADING, UNLOADING AND DEGASSING**

**WITHOUT PERMISSION.**

**CLOSE IMMEDIATELY.**

5.5.2.4.4 Entrances and windows of superstructures and accommodation spaces which can be opened as well as other openings of these spaces are to be located not less than 2 [m] from the cargo area. No wheelhouse doors and windows are to be located within 2 [m] from the cargo area, except where there is no direct connection between the wheelhouse and the accommodation.

5.5.2.4.5 Penetrations

5.5.2.4.5.1 Driving shafts of the bilge or ballast pumps in the cargo area may penetrate through the bulkhead between the

service space and the engine room, provided the arrangement of the service space is in compliance with 5.5.3.1.16, 5.5.3.1.17, 5.5.3.1.18 and 5.5.3.1.19.

5.5.2.4.5.2 The penetration of the shaft through the bulkhead is to be gastight and is to be approved.

5.5.2.4.5.3 The necessary operating instructions are to be displayed.

5.5.2.4.5.4 Penetrations through the bulkhead between the engine room and the service space in the cargo area and the bulkhead between the engine room and the hold spaces may be provided for electrical cables, hydraulic and piping for measuring, control and alarm systems, provided that the penetration are approved. The penetrations are to be gastight. Penetrations through a bulkhead with an "A-60" fire protection insulation are to have an equivalent fire protection.

5.5.2.4.5.5 Pipes may penetrate the bulkhead between the engine room and the service space in the cargo area provided that these are pipes between the mechanical equipment in the engine room and the service space which do not have any openings within the service space and which are provided with shut-off devices at the bulkhead in the engine room.

5.5.2.4.5.6 Notwithstanding **Error! eference source not found.**, pipes from the engine room may pass through the service space in the cargo area or a cofferdam or a hold space or a double-hull space to the outside provided that within the service space or cofferdam or hold space or doublehull space they are of the thick-walled type and have no flanges or openings.

5.5.2.4.5.7 Where a driving shaft of auxiliary machinery penetrates through a wall located above the deck the penetration is to be gastight.

5.5.2.4.6 A service space located within the cargo area below deck is not to be used as a cargo pump room for the loading and unloading system, except where:

- the pump room is separated from the engine room or from service spaces outside the cargo area by a cofferdam or a bulkhead with an "A-60" fire protection insulation or by a service space or a hold space;
- the "A-60" bulkhead required above does not include penetrations referred to in 6.5.7.5.1;
- ventilation exhaust outlets are located not less than 6 [m] from entrances and openings of the accommodation and service spaces outside the cargo area;
- the access hatches and ventilation inlets can be closed from the outside;
- all piping for loading and unloading as well as those of stripping systems are provided with shut-off devices at the pump suction side in the cargo pump-room immediately at the bulkhead. The necessary operation of the control devices in the pump-room, starting of pumps and necessary control of the liquid flow rate is to be effected from the deck;
- the bilge of the cargo pump-room is equipped with a gauging device for measuring the filling level which activates a visual and audible alarm in the wheelhouse when liquid is accumulating in the cargo pump-room bilge;
- the cargo pump-room is provided with a permanent gas–detection system which automatically indicates the presence of explosive gases or lack of oxygen by means of direct-measuring sensors and which actuates a visual and audible alarm when the gas concentration has reached 20% of the lower explosive limit. The sensors of this system are to be placed at suitable positions at the bottom and directly below the deck. Measurement is to be continuous. The audible and visual alarms are installed in the wheelhouse and in the cargo pumproom and, when the alarm is actuated, the loading and unloading system is shut down. Failure of the gas detection system is to be immediately signalled in the wheelhouse and on deck by means of audible and visual alarms;
- the ventilation system prescribed in **Error! Reference source not ound.** has a capacity of not less than 30 changes of air per hour based on the total volume of the service space.

5.5.2.4.7 The following instruction is to be displayed at the entrance of the cargo pump-room:

**BEFORE ENTERING THE CARGO PUMP-ROOM CHECK WHETHER**

**IT IS FREE FROM GASES AND CONTAINS SUFFICIENT OXYGEN.**

**DO NOT OPEN DOORS AND ENTRANCE OPENINGS WITHOUT**

**PERMISSION.**

**LEAVE IMMEDIATELY IN THE EVENT OF ALARM.**

5.5.2.5 Inerting facility

5.5.2.5.1 In cases in which inerting or blanketing of the cargo is prescribed, the vessel is to be equipped with an inerting system.

5.5.2.5.2 This system is to be capable of maintaining a permanent minimum pressure of 7 [kPa] (0.07 bar) in the spaces to be inerted. In addition, the inerting system is not to increase the pressure in the cargo tank to a pressure greater than that at which the pressure valve is regulated. The set pressure of the vacuum-relief valve is to be 3.5 [kPa] (0.035 bar).

5.5.2.5.3 A sufficient quantity of inert gas for loading or unloading is to be carried or produced on board if it is not possible to obtain it on shore. In addition, a sufficient quantity of inert gas to offset normal losses occurring during carriage is to be on board.

5.5.2.5.4 The premises to be inerted are to be equipped with connections for introducing the inert gas and monitoring systems so as to ensure the correct atmosphere on a permanent basis.

5.5.2.5.5 When the pressure or the concentration of inert gas in the gaseous phase falls below a given value, this monitoring system is to activate an audible and visible alarm in the wheelhouse. When the wheelhouse is unoccupied, the alarm is to also be perceptible in a location occupied by a crew member.

5.5.2.6 Cofferdam Arrangements

5.5.2.6.1 Cofferdams or cofferdam compartments remaining once a service space has been arranged in accordance with 5.5.3.1.16, 5.5.3.1.17, 5.5.3.1.18 and 5.5.3.1.19 are to be accessible through an access hatch.

5.5.2.6.2 Cofferdams are to be capable of being filled with water and emptied by means of a pump. Filling is to be effected within 30 minutes. These requirements are not applicable when the bulkhead between the engine room and the cofferdam comprises fire-protection insulation “A-60” or has been fitted out as a service space. The cofferdams are not to be fitted with inlet valves.

5.5.2.6.3 No fixed pipe is to permit connection between a cofferdam and other piping of the vessel outside the cargo area.

5.5.2.6.4 When the list of substances on the vessel contains substances for which protection against explosion is required in column (17) of Table C of Chapter 3.2 of ADN, the ventilation openings of cofferdams are to be fitted with a flame-arrester withstanding a deflagration.

5.5.2.7 Engines

~~5.5.2.7.1~~ Only internal combustion engines running on fuel with a flashpoint of more than 55º C are allowed.

5.5.2.7.2 Ventilation inlets of the engine room, and when the engines do not take in air directly from the engine room, air intakes of the engines are to be located not less than 2 [m] from the cargo area.

5.5.2.7.3 Sparking is not to be possible within the cargo area.

5.5.2.7.4 The surface temperature of the outer parts of engines used during loading or unloading operations, as well as that of their air inlets and exhaust ducts is not to exceed the allowable temperature according to the temperature class of the substances carried. This provision does not apply to engines installed in service spaces provided the provisions of 5.5.9.3.7 are fully complied with.

5.5.2.7.5 The ventilation in the closed engine room is to be designed so that, at an ambient temperature of 20 °C, the average temperature in the engine room does not exceed 40º C.

5.5.2.8 Oil fuel tanks

5.5.2.8.1 Where the vessel is provided with hold spaces, the double bottoms within these spaces may be arranged as oil fuel tanks, provided their depth is not less than 0.6 [m]. Oil fuel pipes and openings of such tanks are not permitted in the hold space.

5.5.2.8.2 The open ends of the air pipes of all oil fuel tanks are to extend to not less than 0.5 [m] above the open deck. Their open ends and the open ends of overflow pipes leading to the deck are to be fitted with a protective device consisting of a gauze diaphragm or a perforated plate.

5.5.2.9 Exhaust pipes

5.5.2.9.1 Exhausts are to be evacuated from the vessel into the open air either upwards through an exhaust pipe or through the shell plating. The exhaust outlet is to be located not less than 2 [m] from the cargo area. The exhaust pipes of engines are to be arranged so that the exhausts are led away from the vessel. The exhaust pipes are not to be located within the cargo area.

5.5.2.9.2 Exhaust pipes are to be provided with a device preventing the escape of sparks, e.g. spark arresters.

5.5.2.10 Bilge pumping and ballasting arrangements

5.5.2.10.1 Bilge and ballast pumps for spaces within the cargo area are to be installed within such area.

This provision does not apply to:

- double-hull spaces and double bottoms which do not have a common boundary wall with the cargo tanks;
- cofferdams, double-hull spaces, hold spaces and double bottoms where ballasting is carried out using the piping of the fire-fighting system in the cargo area and bilge pumping is performed using eductors.

5.5.2.10.2 Where the double bottom is used as a liquid oil fuel tank, it is not to be connected to the bilge piping system.

5.5.2.10.3 Where the ballast pump is installed in the cargo area, the standpipe and its outboard connection for suction of ballast water is to be located within the cargo area but outside the cargo tanks.

5.5.2.10.4 A cargo pump-room below deck is to be capable of being drained in an emergency by an installation located in the cargo area and independent from any other installation. This installation is to be provided outside the cargo pump-room.

5.5.3 Cargo Containment

5.5.3.1 Hold spaces and cargo tanks

5.5.3.1.1 The maximum permissible capacity of a cargo tank is to be determined in accordance with the following table:

**Table 4: Tank Sizes**

| Loa x Boa x D, in $m^3$ | Maximum permissible capacity of a cargo tank ($m^3$) |
|---|---|
| $\leq 600$ | Loa x Boa x D x 0.3 |
| 600 – 3750 | 180 + (Loa x Boa x D – 600) x 0.0635 |
| > 3750 | 380 |

where:

$L_{OA}$ X $B_{OA}$ X D : Product of the tank vessel main dimensions, in [$m^3$]

$L_{OA}$ : overall length of the hull, in [m]

$B_{OA}$ : extreme breadth in [m]

D : Shortest vertical distance between the top of the keel and the lowest point of the deck at the side of the vessel; (moulded depth) within the cargo area in [m].

5.5.3.1.2 Alternative constructions in compliance with Chapter 9, 9.3.4 of ADN are acceptable

5.5.3.1.3 The relative density of the substances to be carried is to be taken into consideration in the design of the cargo tanks. The maximum relative density is to be indicated in the certificate of approval;

5.5.3.1.4 When the vessel is provided with pressure cargo tanks, these tanks are to be designed for a working pressure of 400 [kPa] (4 bar);

5.5.3.1.5 The cargo tank is to comply with the following:

- For vessels with a length of not more than 50 [m], the length of a cargo tank is not to exceed 10 [m];
- For vessels with a length of more than 50 [m], the length of a cargo tank is not to exceed 0.20 L;

This provision does not apply to vessels with independent built–in cylindrical tanks having a length to diameter ratio ≤ 7.

5.5.3.1.6 In the cargo area (except cofferdams) the vessel is to be designed as a flush–deck double-hull vessel, with double-hull spaces and double bottoms, but without a trunk; Cargo tanks independent of the vessel's hull and refrigerated cargo tanks may only be installed in a hold space which is bounded by double-hull spaces and double bottoms in accordance with 5.5.3.1.20 below. The cargo tanks are not to extend beyond the deck. Refrigerated cargo tank fastenings are to meet the requirements 3.6.4.

5.5.3.1.7 The cargo tanks independent of the vessel's hull are to be fixed so that they cannot float;

5.5.3.1.8 The capacity of a suction well is to be limited to not more than 0.10 [$m^3$].

5.5.3.1.9 Side–struts linking or supporting the load-bearing components of the sides of the vessel with the load-bearing components of the longitudinal walls of cargo tanks and side–struts linking the load-bearing components of the vessel's bottom with the tank-bottom are prohibited;

5.5.3.1.10 A local recess in the cargo deck, contained on all sides, with a depth greater than 0.1 [m], designed to house the loading and unloading pump, is permitted if it fulfils the following conditions:

- The recess is not to be greater than 1 [m] in depth;
- The recess is to be located not less than 6 [m] from entrances and openings to accommodation and service spaces outside the cargo area;
- The recess is to be located at a minimum distance from the side plating equal to one quarter of the vessel's breadth;
- All pipes linking the recess to the cargo tanks are to be fitted with shut-off devices fitted directly on the bulkhead;
- All the controls required for the equipment located in the recess are to be activated from the deck;
- If the recess is deeper than 0.5 [m], it is to be provided with a permanent gas detection system which automatically indicates the presence of explosive gases by means of direct-measuring sensors and actuates a visual and audible alarm when the gas concentration has reached 20% of the lower explosion limit. The sensors of this system are to be placed at suitable positions at the bottom of the recess. Measurement is to be continuous;
- Visual and audible alarms are to be installed in the wheelhouse and on deck and, when the alarm is actuated, the vessel loading and unloading system is to be shut down. Failure of the gas detection system is to be immediately signalled in the wheelhouse and on deck by means of visual and audible alarms;
- It is to be possible to drain the recess using a system installed on deck in the cargo area and independent of any

other system;

- The recess is to be provided with a level alarm device which activates the draining system and triggers a visual and audible alarm in the wheelhouse when liquid accumulates at the bottom;
- When the recess is located above the cofferdam, the engine room bulkhead is to have an 'A-60' fire protection insulation
- When the cargo area is fitted with a water-spray system, electrical equipment located in the recess is to be protected against infiltration of water;
- Pipes connecting the recess to the hull are not to pass through the cargo tanks.

5.5.3.1.11 The cargo tanks are to be separated by cofferdams of at least 0.60 [m] in width from the accommodation, engine rooms and service spaces outside the cargo area below deck or, if there are no such accommodation, engine rooms and service spaces, from the vessel's ends. Where the cargo tanks are installed in a hold space, a space of not less than 0.50 [m] is to be provided between such tanks and the end bulkheads of the hold space. In this case an end bulkhead meeting at least the definition for Class "A-60" is to be deemed equivalent to a cofferdam. For pressure cargo tanks, the 0.50 [m] distance may be reduced to 0.20 [m];

5.5.3.1.12 Hold spaces, cofferdams and cargo tanks are to be capable of being inspected;

5.5.3.1.13 All spaces in the cargo area are to be capable of being ventilated. Means for checking their gas-free condition is to be provided.

5.5.3.1.14 The bulkheads bounding the cargo tanks, cofferdams and hold spaces are to be watertight. The cargo tanks and the bulkheads bounding the cargo area are to have no openings or penetrations below deck. The bulkhead between the engine room and the cofferdam or service space in the cargo area or between the engine room and a hold space may be fitted with penetrations provided that they conform to the provisions of 5.5.2.4.5. The bulkhead between the cargo tank and the cargo pump-room below deck may be fitted with penetrations provided that they conform to the provisions of 5.5.2.4.6. The bulkheads between the cargo tanks may be fitted with penetrations provided that the loading or unloading piping are fitted with shut-off devices in the cargo tank from which they come. These shut-off devices are to be operable from the deck.

5.5.3.1.15 Double-hull spaces and double bottoms in the cargo area are to be arranged for being filled with ballast water only. Double bottoms may, however, be used as oil fuel tanks, provided they comply with the provisions of 5.5.2.8.

5.5.3.1.16 A cofferdam, the centre part of a cofferdam or another space below deck in the cargo area may be arranged as a service space, provided the bulkheads bounding the service space extend vertically to the bottom. This service space is only to be accessible from the deck;

5.5.3.1.17 The service space is to be watertight with the exception of its access hatches and ventilation inlets;

5.5.3.1.18 No piping for loading and unloading is to be fitted within the service space referred to under 5.5.3.1.16 above;

5.5.3.1.19 Piping for loading and unloading may be fitted in the cargo pump-rooms below deck only when they conform to the provisions of 5.5.2.4.6.

5.5.3.1.20 For double-hull construction with the cargo tanks integrated in the vessel's structure, the distance between the side wall of the vessel and the longitudinal bulkhead of the cargo tanks is to be not less than 1 [m]. The distance may be reduced to 0.80 [m], provided that, the following reinforcements have been made:

a) 25% increase in the thickness of the deck stringer plate;

b) 15% increase in the side plating

thickness;

c) Arrangement of a longitudinal framing system at the vessel's side, where depth of the longitudinals are to be not less than 0.15 [m] and the longitudinals are to have a face plate with the cross-sectional area of at least 7.0 [$cm^2$];

d) The stringer or longitudinal framing systems are to be supported by web frames, and like bottom girders fitted with lightening holes, at a maximum spacing of 1.80 [m]. These distances may be increased if the longitudinals are strengthened accordingly.

When a vessel is built according to the transverse framing system, a longitudinal stringer system is to be arranged instead of (c) above. The distance between the longitudinal stringers is not to exceed 0.80 [m] and their depth is to be not less than 0.15 [m], provided they are completely welded to the frames. The cross-sectional area of the facebar or faceplate is to be not less than 7.0 [$cm^2$] as in (c) above. Where cut-outs are arranged in the stringer at the connection with the frames, the web depth of the stringer is to be increased with the depth of cut-outs.

The mean depth of the double bottoms is to be not less than 0.70 [m]. It is to be, however, never be less than 0.60 [m]. The depth below the suction wells may be reduced to 0.50 [m].

Alternative constructions in accordance with Chapter 9, 9.3.4 of ADN are acceptable.

5.5.3.1.21 When a vessel is built with cargo tanks located in a hold space or refrigerated cargo tanks, the distance between the double walls of the hold space is to be not less than 0.80 [m] and the depth of the double bottom is to be not less than 0.60 [m].

5.5.3.1.22 Where service spaces are located in the cargo area under deck, they are to be arranged so as to be easily accessible and to permit persons wearing protective clothing and breathing apparatus to safely operate the service equipment contained therein. They are to be designed so as to allow injured or unconscious personnel to be removed from such spaces without difficulties, if necessary by means of fixed equipment.

5.5.3.1.23 Cofferdams, double-hull spaces, double bottoms, cargo tanks, hold spaces and other accessible spaces within the cargo area are to be arranged so that they may be completely inspected and cleaned in an appropriate manner. The dimensions of openings except for those of double-hull spaces and double bottoms which do not have a wall adjoining the cargo tanks are to be sufficient to allow a person wearing breathing apparatus to enter or leave the space without difficulties. These openings are to have a minimum cross-sectional area of 0.36 [$m^2$] and a minimum side length of 0.50 [m]. They are to be designed so as to allow an injured or unconscious person to be removed from the bottom of such a space without difficulties, if necessary by means of fixed equipment. In these spaces the distance between the reinforcements are not to be less than 0.50 [m]. In double bottoms this distance may be reduced to 0.45 [m]. Cargo tanks may have circular openings with a diameter of not less than 0.68 [m].

5.5.3.2 Cargo tank openings

5.5.3.2.1 Cargo tank openings are to be located on deck in the cargo area.

5.5.3.2.2 Cargo tank openings with a cross-section of more than 0.10 [$m^2$] and openings of safety devices for preventing overpressures are to be located not less than 0.50 [m] above deck.

5.5.3.2.3 Cargo tank openings are to be fitted with gastight closures capable of withstanding the test pressure in accordance with 5.5.10.1.2.

5.5.3.2.4 Closures which are normally used during loading or unloading operations are not to cause sparking when operated.

5.5.3.2.5 Each cargo tank or group

of cargo tanks connected to a common venting piping are to be fitted with:

- safety devices for preventing unacceptable overpressures or vacuums. When anti-explosion protection is required in column (17) of Table C of Chapter 3.2 of ADN, the vacuum valve is to be fitted with a flame arrester capable of withstanding a deflagration and the pressure–relief valve with a high-velocity vent valve capable of withstanding steady burning. The gases are to be discharged upwards. The opening pressure of the high velocity vent valve and the opening pressure of the vacuum valve is to be indelibly indicated on the valves;
- a connection for the safe return ashore of gases expelled during loading;
- a device for the safe depressurization of the tanks. When the list of substances on the vessel contains substances for which protection against explosion is required in column (17) of Table C of Chapter 3.2 of ADN, this device is to include at least a flame arrester capable of withstanding steady burning and a stop valve which clearly indicates whether it is open or shut.

5.5.3.2.6 The outlets of high-velocity vent valves are to be located not less than 2 [m] above the deck and at a distance of not less than 6 [m] from the accommodation and from the service spaces outside the cargo area. This height may be reduced when within a radius of 1 [m] round the outlet of the high-velocity vent valve, there is no equipment, no work is being carried out and signs indicate the area. The setting of the high-velocity vent valves is to be such that during the transport operation they do not blow off until the maximum permissible working pressure of the cargo tanks is reached.

5.5.3.2.7 One of the following is to be complied with:

5.5.3.2.7.1 Insofar as anti-explosion protection is prescribed in column (17) of Table C of Chapter 3.2 of ADN, venting piping connecting two or more cargo tanks is to be fitted, at the connection to each cargo tank, with a flame arrester with a fixed or spring-loaded plate stack, capable of withstanding a detonation. This equipment may consist of:

- a flame arrester fitted with a fixed plate stack, where each cargo tank is fitted with a vacuum valve capable of withstanding a deflagration and a high-velocity vent valve capable of withstanding steady burning;
- a flame arrester fitted with a spring-loaded plate stack, where each cargo tank is fitted with a vacuum valve capable of withstanding a deflagration;
- a flame arrester with a fixed or spring-loaded plate stack;
- a flame arrester with a fixed plate stack, where the pressure–measuring device is fitted with an alarm system in accordance with 5.5.5.8.1, 5.5.5.8.2 and 5.5.5.8.3;

  When a fire-fighting installation is permanently mounted on deck in the cargo area and can be brought into service from the deck and from the wheelhouse, flame arresters need not be required for individual cargo tanks. Only substances which do not mix and which do not react dangerously with each other may be carried simultaneously in cargo tanks connected to a common venting piping; or,

5.5.3.2.7.2 Insofar as anti-explosion protection is prescribed in column (17) of Table C of Chapter 3.2 of ADN, venting piping connecting two or more cargo tanks are to be fitted, at the connection to each cargo tank, with a pressure/vacuum relief valve incorporating a flame arrester capable of withstanding a detonation/deflagration. Only substances which do not mix and which do not react dangerously with each other may be carried simultaneously in cargo tanks connected to a common venting piping; or,

5.5.3.2.7.3 Insofar as anti-explosion

protection is prescribed in column (17) of Table C of Chapter 3.2 of ADN, an independent venting piping for each cargo tank, fitted with a vacuum valve incorporating a flame arrester capable of withstanding a deflagration and a high velocity vent valve incorporating a flame arrester capable of withstanding steady burning. Several different substances may be carried simultaneously;or,

5.5.3.2.7.4 Insofar as anti-explosion protection is prescribed in column (17) of Table C of Chapter 3.2 of ADN, venting piping connecting two or more cargo tanks are to be fitted, at the connection to each cargo tank, with a shut-off device capable of withstanding a detonation, where each cargo tank is fitted with a vacuum valve capable of withstanding a deflagration and a high-velocity vent valve capable of withstanding steady burning.

Only substances which do not mix and which do not react dangerously with each other may be carried simultaneously in cargo tanks connected to a common venting piping.

5.5.4 Stability

5.5.4.1 General

5.5.4.1.1 Proof of sufficient stability is to be submitted including for stability in damaged condition.

5.5.4.1.2 The basic values for the stability calculation, the vessel's lightweight and location of the centre of gravity, are to be determined either by means of an inclining experiment or by detailed mass and moment calculation. In the latter case the lightweight of the vessel is to be checked by means of a lightweight test with a tolerance limit of ± 5% between the mass determined by calculation and the displacement determined by the draught readings.

5.5.4.1.3 Proof of sufficient intact stability is to be submitted for all stages of loading and unloading and for the final loading condition for all the relative densities of the substances transported contained in the list of cargoes. For every loading operation, taking account of the actual fillings and floating position of cargo tanks, ballast tanks and compartments, drinking water and sewage tanks and tanks containing products for the operation of the vessel, the vessel is to comply with the intact and damage stability requirements. Intermediate stages during operations are also to be taken into consideration. The proof of sufficient stability is to be shown for every operating, loading and ballast condition in the stability booklet, to be approved. If it is unpractical to pre-calculate the operating, loading and ballast conditions, an approved loading instrument is to be installed and used which contains the contents of the stability booklet.

5.5.4.1.4 Floatability after damage is to be proved for the most unfavourable loading condition. For this purpose, calculated proof of sufficient stability is to be established for critical intermediate stages of flooding and for the final stage of flooding.

5.5.4.2 Intact stability

5.5.4.2.1 The requirements for intact stability resulting from the damage stability calculation are to be fully complied with.

5.5.4.2.2 For vessels with cargo tanks of more than 0.70 B in width, proof is to be submitted that the following stability requirements have been complied with:

a) In the positive area of the righting lever curve up to immersion of the first non-watertight opening there is to be a righting lever (GZ) of not less than 0.10 [m];

b) The surface of the positive area of the righting lever curve up to immersion of the first non-watertight opening and in any event up to an angle of heel < 27°is not to be less than 0.024 [m.rad];

c) The metacentric height (GM) is to be not less than 0.10 [m].

These conditions are to be met bearing in mind the influence of all free surfaces in tanks for all stages of loading and unloading.

5.5.4.2.3 The most stringent requirement of 5.5.4.2.1 and 5.5.4.2.2 is applicable to the vessel.

5.5.4.3 Damage stability

5.5.4.3.1 The following assumptions are to be taken into consideration for the damaged condition:

a) extent of side damage:

| | |
|---|---|
| l) Longitudinal extent: | m) At least 0.10 LOA, but not less than 5 [m] |
| n) | o) |
| p) Transverse extent : | q) 0.79 [m] inboard from the vessel's side at right angles to the centerline at the level corresponding to the maximum draught , or when applicable, the distance allowed by sec Chapter 9, 9.3.4 of ADN, reduced by 0.01[m] |
| r) | s) |
| t) Vertical extent : | u) From the base line upwards without limit |

b) extent of bottom damage:

| | |
|---|---|
| Longitudinal extent: | At least 0.10 $L_{OA}$, but not less than 5 [m] |
| Transverse extent : | 3 [m] |
| Vertical extent : | From the base 0.59[m] upwards, the sump excepted |

c) Any bulkhead within the damaged area is to be assumed damaged, which means that the location of bulkheads is to be chosen to ensure that the vessel remains afloat after the flooding of two or more adjacent compartments in the longitudinal direction.

The following provisions are applicable:

- For bottom damage, adjacent athwartship compartments are also to be assumed flooded
- the lower edge of any non-watertight opening (e.g. windows, doors and access hatchways), at the final stage of flooding, is to be not less than 0.10 [m] above the damage waterline.
- In general, permeability is to be assumed to be 95%. Where an average permeability of less than 95% is calculated for any compartment, this calculated value obtained may be used. However, minimum values of permeability, μ, given in **Table 5** are to be used. For the main engine room, only the one-compartment standard need be taken into account, i.e. the end bulkheads of the engine room are to be assumed as not damaged.

| **Table 5: Permeability** | |
|---|---|
| Engine Room | 85% |
| Accommodation | 95% |
| Double Bottom, Oil Fuel Tanks, Ballast Tanks, etc. depending on whether, according to their function, they have to be assumed as full or empty for vessel floating at the maximum permissible draft | 0% or 95% |

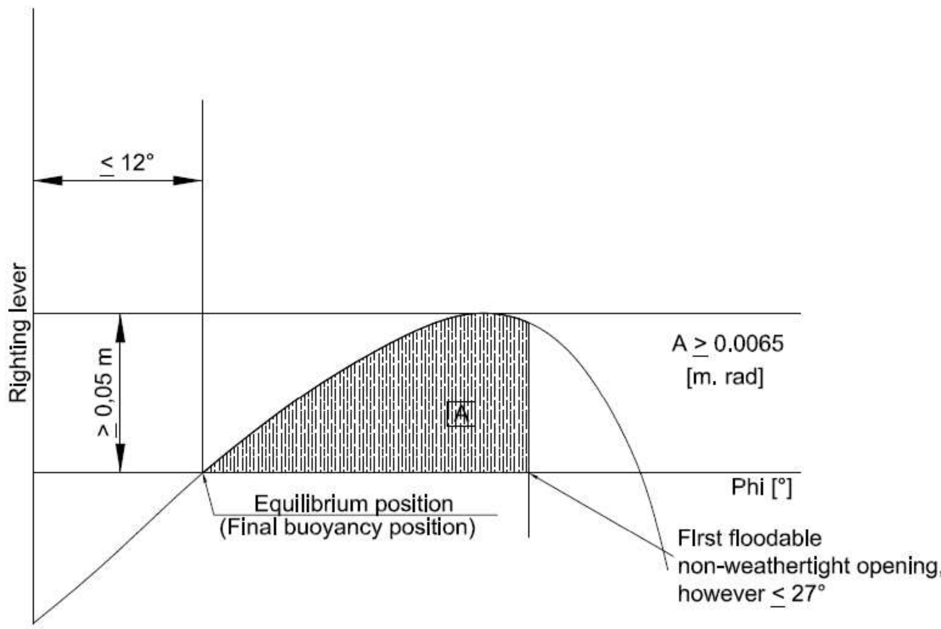
5.5.4.3.2 For the intermediate stage of flooding the following criteria have to be fulfilled:

GZ≥0.03[m]

Range of positive GZ: 5°

5.5.4.3.3 At the stage of equilibrium (in the final stage of flooding), the angle of heel is not to exceed 12°. Non-watertight openings are not to be flooded before reaching the stage of equilibrium. If such openings are immersed before the stage of equilibrium, the corresponding spaces are to be considered flooded for the purpose of stability calculation.

5.5.4.3.4 The positive range of the righting lever curve beyond the stage of equilibrium is to have a righting lever of ≥ 0.05 [m] in association with an area under the curve of ≥ 0.0065 [m.rad]. The minimum values of stability are to be satisfied up to immersion of the first non-weathertight openings and in any event up to an angle of heel ≤ 27°. If nonwatertight openings are immersed before that stage, the corresponding spaces are to be considered flooded for the purpose of stability calculation.




5.5.4.3.5 If openings through which undamaged compartments may additionally become flooded are capable of being closed watertight, the closing appliances are to be marked accordingly.

5.5.4.3.6 Where cross- or down-flooding openings are provided for reduction of unsymmetrical flooding, the time of equalization is not to exceed 15 min, provided during the intermediate stages of flooding sufficient stability has been proved.

5.5.5 Safety and control installations

5.5.5.1 Cargo tanks are to be provided with the following equipment:

a) a mark inside the tank indicating the liquid level of 95%;

b) a level gauge;

c) a level alarm device which is activated at the latest when a degree of filling of 90% is reached;

d) a high level sensor for actuating the facility against overflowing at the latest when a degree of filling of 97.5% is reached;

e) an instrument for measuring the pressure of the vapour phase inside the cargo tank;

f) an instrument for measuring the temperature of the cargo, if in column (9) of Table C of Chapter 3.2 of ADN a heating installation is required, or if a maximum temperature is indicated in column

(20) of that list;

g) a connection for a closed-type or partly closed-type sampling device, and/or at least one sampling opening as required in column (13) of Table C of Chapter 3.2 of ADN.

5.5.5.2 When the degree of filling in per cent is determined, an error of not more than 0.5% is permitted. It is to be calculated on the basis of the total cargo tank capacity including the expansion trunk.

5.5.5.3 The level gauge is to allow readings from the control position of the shut-off devices of the particular cargo tank. The permissible maximum filling levels of 95% and 97%, as given in the list of substances, are to be marked on each level gauge. Permanent reading of the overpressure and vacuum is to be possible from a location from which loading or unloading operations may be interrupted. The permissible maximum overpressure and vacuum are to be marked on each level gauge. Readings are to be possible in all weather conditions.

5.5.5.4 The level alarm device is to give a visual and audible warning on board when actuated. The level alarm device is to be independent of the level gauge.

5.5.5.5 High Level Sensors

5.5.5.5.1 The high level sensor referred to in 5.5.5.1d) above is to give a visual and audible alarm on board and at the same time actuate an electrical contact which in the form of a binary signal interrupts the electric current loop provided and fed by the shore facility, thus initiating measures at the shore facility against overflowing during loading operations. The signal is to be transmitted to the shore facility via a watertight two–pin plug of a connector device in accordance with standard EN 60309 for direct current of 40 to 50 volts, identification colour white, position of the nose 10 h. The plug is to be permanently fitted to the vessel close to the shore connections of the loading and unloading piping.

5.5.5.5.2 The high level sensor is also to be capable of switching off the vessel's own discharging pump.

5.5.5.5.3 The high level sensor is to be independent of the level alarm device, but it may be connected to the level gauge.

5.5.5.5.4 During discharging by means of the on-board pump, it is to be possible for the shore facility to switch it off. For this purpose, an independent intrinsically safe power line, fed by the vessel, is to be switched off by the shore facility by means of an electrical contact. It is to be possible for the binary signal of the shore facility to be transmitted via a watertight two–pole socket or a connector device in accordance with standard EN 60309, for direct current of 40 to 50 volts, identification colour white, position of the nose 10 h. This socket is to be permanently fitted to the vessel close to the shore connections of the unloading piping.

5.5.5.6 Vessels which may be delivering products required for operation of vessels are to be equipped with a transhipment facility compatible with European standard EN 12827:1999 and a rapid closing device enabling refuelling to be interrupted. It is to be possible to actuate this rapid closing device by means of an electrical signal from the overflow prevention system. The electrical circuits actuating the rapid closing device are to be secured according to the quiescent current principle or other appropriate error detection measures. The state of operation of electrical circuits which cannot be controlled using the quiescent current principle are to be capable of being easily checked. It is to be possible to actuate the rapid closing device independently of the electrical signal. The rapid closing device is to actuate a visual and audible alarm on board.

5.5.5.7 The visual and audible signals given by the level alarm device are to be clearly distinguishable from those of the high level sensor. The visual alarm is to be visible at each control position on deck of the cargo tank stop valves. It is to be possible to easily check the functioning of the sensors and electric circuits or these are to be "intrinsically safe apparatus".

5.5.5.8 Cargo tank pressure and temperature monitoring

5.5.5.8.1 When the pressure or temperature exceeds a set value, instruments for measuring the vacuum or overpressure of the gaseous phase in the cargo tank or the temperature of the cargo, is to activate a visual and audible alarm in the wheelhouse. When the wheelhouse is unoccupied the alarm

is also to be perceptible in a location occupied by a crew member.

5.5.5.8.2 When the pressure exceeds the set value during loading and unloading, the instrument for measuring the pressure is to, by means of the plug referred to in 5.5.5.5 and **Error! Reference ource not found.** above, initiate immediately an electrical contact which is to put into effect measures to interrupt the loading or unloading operation. If the vessel's own discharge pump is used, it is to be switched off automatically. The instrument for measuring the overpressure or vacuum is to activate the alarm at latest when an overpressure is reached equal to 1.15 times the opening pressure of the pressure relief device, or a vacuum pressure equal to the construction vacuum pressure but not exceeding 5 [kPa] (0.05 bar). The maximum allowable temperature is indicated in column (20) of Table C of Chapter 3.2 of ADN. The sensors for the alarms mentioned in this paragraph may be connected to the alarm device of the sensor.

5.5.5.8.3 When it is prescribed in column (20) of Table C of Chapter 3.2 of ADN, the instrument for measuring the overpressure of the gaseous phase is to activate a visible and audible alarm in the wheelhouse when the overpressure exceeds 40 [kPa] (0.4 bar) during the voyage. When the wheelhouse is unoccupied, the alarm is also to be perceptible in a location occupied by a crew member.

5.5.5.9 Where the control elements of the shut-off devices of the cargo tanks are located in a control room, it is to be possible to stop the loading pumps and read the level gauges in the control room, and the visual and audible warning given by the level alarm device, the high level sensor referred to in 5.5.5.1d) and the instruments for measuring the pressure and temperature of the cargo are to be noticeable in the control room and on deck. Satisfactory monitoring of the cargo area is to be ensured from the control room.

5.5.5.10 The vessel is to be so equipped that loading or unloading operations can be interrupted by means of switches, i.e. the quick-action stop valve located on the flexible vessel–to–shore connecting line must be capable of being closed. The switch is to be placed at two points on the vessel (fore and aft). This provision applies only when prescribed in column (20) of Table C of Chapter 3.2 of ADN. The interruption system is to be designed according to the quiescent current principle.

5.5.5.11 When refrigerated substances are carried the opening pressure of the safety system is to be determined by the design of the cargo tanks. In the event of the transport of substances that must be carried in a refrigerated state the opening pressure of the safety system is to be not less than 25 [kPa] (0.25 bar) greater than the maximum pressure calculated according to 5.5.6.2.

5.5.6 Cargo Pressure and Temperature Control

5.5.6.1 Requirements for maintenance of cargo pressure and temperature

5.5.6.1.1 Unless the entire cargo system is designed to resist the full effective vapour pressure of the cargo at the upper limits of the ambient design temperatures, the pressure of the tanks is to be kept below the permissible maximum set pressure of the safety valves, by one or more of the following means:

a) a system for the regulation of cargo tank pressure using mechanical refrigeration;

b) a system ensuring safety in the event of the heating or increase in pressure of the cargo. The insulation or the design pressure of the cargo tank, or the combination of these two elements, is to be such as to leave an adequate margin for the operating period and the temperatures expected; in each case the system is to be deemed acceptable and is to ensure safety for a minimum time of three times the operation period;

5.5.6.1.2 The systems prescribed in 5.5.6.1.1 are to be constructed, installed and tested. The materials used in their construction are to be compatible with the cargoes to be carried. For normal service, the upper ambient design temperature limits are to be:

Air: +45° C;

Water: +32° C.

5.5.6.1.3 The cargo storage system

is to be capable of resisting the full vapour pressure of the cargo at the upper limits of the ambient design temperatures, whatever the system adopted to deal with the boil-off gas. This requirement is indicated by remark 37 in column (20) of Table C of Chapter 3.2 of ADN.

5.5.6.2 Refrigeration system

5.5.6.2.1 The refrigeration system referred to in 5.5.6.1.1a) is to be composed of one or more units capable of keeping the pressure and temperature of the cargo at the upper limits of the ambient design temperatures at the prescribed level. Unless another means of regulating cargo pressure and temperature deemed satisfactory by Designated Authority/Classification Society, provision is to be made for one or more stand-by units with an output at least equal to that of the largest prescribed unit. A stand-by unit is to include a compressor, its engine, its control system and all necessary accessories to enable it to operate independently of the units normally used. Provision is to be made for a stand-by heat-exchanger unless the system's normal heat-exchanger has a surplus capacity equal to at least 25% of the largest prescribed capacity. It is not necessary to make provision for separate piping. Cargo tanks, piping and accessories are to be insulated so that, in the event of a failure of all cargo refrigeration systems, the entire cargo remains for at least 52 hours in a condition not causing the safety valves to open.

5.5.6.2.2 The security devices and the connecting lines from the refrigeration system are to be connected to the cargo tanks above the liquid phase of the cargo when the tanks are filled to their maximum permissible degree of filling. They are to remain within the gaseous phase, even if the vessel has a list up to 12 degrees.

5.5.6.2.3 When several refrigerated cargoes with a potentially dangerous chemical reaction are carried simultaneously, particular care is to be given to the refrigeration systems to prevent any mixing of the cargoes. For the carriage of such cargoes, separate refrigeration systems, each including the full stand-by unit referred to in **Error! Reference ource not found.**, is to be provided for each cargo. When, however, refrigeration is ensured by an indirect or combined system and no leak in the heat exchangers can under any foreseeable circumstances lead to the mixing of cargoes, no provision need be made for separate refrigeration units for the different cargoes.

5.5.6.2.4 When several refrigerated cargoes are not soluble in each other under conditions of carriage such that their vapour pressures are added together in the event of mixing, particular care is to be given to the refrigeration systems to prevent any mixing of the cargoes.

5.5.6.2.5 When the refrigeration systems require water for cooling, a sufficient quantity is to be supplied by a pump or pumps used exclusively for the purpose. This pump or pumps are to have at least two suction pipes, leading from two water intakes, one to port, the other to starboard. Provision is to be made for a stand-by pump with a satisfactory flow; this may be a pump used for other purposes provided that its use for supplying water for cooling does not impair any other essential service.

5.5.6.2.6 The refrigeration system may take one of the following forms:

a) Direct system: the cargo vapours are compressed, condensed and returned to the cargo tanks. This system is not to be used for certain cargoes specified in Table C of Chapter 3.2 of ADN. This requirement is indicated by remark 35 in column (20) of Table C of Chapter 3.2 of ADN;

b) Indirect system: the cargo or the cargo vapours are cooled or condensed by means of a coolant without being compressed;

c) Combined system: the cargo vapours are compressed and condensed in a cargo/coolant heat-exchanger and returned to the cargo tanks. This system is not to be used for certain cargoes specified in Table C of Chapter 3.2 of ADN. This requirement is indicated by remark 36 in column (20) of Table C of Chapter 3.2 of ADN.

5.5.6.2.7 All primary and secondary coolant fluids are to be compatible with each other and with the cargo with which they may come into contact. Heat exchange may take place either at a distance from the cargo tank, or by using cooling coils attached to the inside or the outside of the cargo tank.

5.5.6.2.8 When the refrigeration system is installed in a separate service space, this service space is to meet the requirements of 5.5.2.4.6.

5.5.6.2.9 For all cargo systems, the heat transmission coefficient as used for the determination of the holding time is to be determined by calculation. Upon completion of the vessel, the correctness of the calculation is to be checked by means of a heat balance test. The calculation and test is to be performed under supervision by Designated Authority/Classification Society. The heat transmission coefficient is to be documented and kept on board. The heat transmission coefficient is to be verified at every renewal of the certificate of approval.

5.5.6.3 Cargo heating system

5.5.6.3.1 Boilers, which are used for heating the cargo, are to be fueled with a liquid fuel having a flashpoint of more than 55 °C. They are to be placed either in the engine room or in another separate space below deck and outside the cargo area, which is accessible from the deck or from the engine room.

5.5.6.3.2 The cargo heating system is to be designed so that the cargo cannot penetrate into the boiler in the case of a leak in the heating coils. A cargo heating system with artificial draught is to be ignited electrically.

5.5.6.3.3 The ventilation system of the engine room is to be designed taking into account the air required for the boiler.

5.5.6.3.4 Where the cargo heating system is used during loading, unloading or gas-freeing, the service space which contains this system is to fully comply with the requirements of 5.5.9.3.7. This requirement does not apply to the inlets of the ventilation system. These inlets are to be located at a minimum distance of 2 [m] from the cargo area and 6 [m] from the openings of cargo tanks or residual cargo tanks, loading pumps situated on deck, openings of high velocity vent valves, pressure relief devices and shore connections of loading and unloading piping and must be located not less than 2 [m] above the deck. The requirements of 5.5.9.3.7.are not applicable to the unloading of substances having a flash point of 60 [°C] or more when the temperature of the product is at least 15 K lower at the flash point.

5.5.6.4 Water-spray system

5.5.6.4.1 When water-spraying is required in column (9) of Table C of Chapter 3.2 of ADN, a water-spray system is to be installed in the cargo area on deck to enable gas emissions from loading to be precipitated and to cool the tops of cargo tanks by spraying water over the whole surface so as to avoid safely the activation of the high-velocity vent valve at 50 [kPa] (0.5 bar). The gas precipitation system is to be fitted with a connection device for supply from a shore installation.

5.5.6.4.2 The spray nozzles are to be so installed that the entire cargo deck area is covered and the gases released are precipitated safely. The system is to be capable of being put into operation from the wheelhouse and from the deck. Its capacity is to be such that when all the spray nozzles are in operation, the outflow

is not less than 50 litres per square metre of deck area and per hour.

5.5.7 Pumps and piping

5.5.7.1 Pumps, compressors and accessory loading and unloading piping are to be placed in the cargo area. Cargo pumps are to be capable of being shut down from the cargo area and, in addition, from a position outside the cargo area. Cargo pumps situated on deck are to be located not less than 6 [m] from entrances to, or openings of, the accommodation and service spaces outside the cargo area.

5.5.7.2 Piping for loading and unloading is to be independent of any other piping of the vessel. No cargo piping is to be located below deck, except those inside the cargo tanks and inside the cargo pump-room.

5.5.7.3 The piping for loading and unloading is to be arranged so that, after loading or unloading operations, the liquid remaining in these pipes may be safely removed and may flow either into the vessel's tanks or the tanks ashore.

5.5.7.4 Piping for loading and unloading is to be clearly distinguishable from other piping, e.g. by means of colour marking.

5.5.7.5 The piping for loading and unloading located on deck, with the exception of the shore connections, is to be located not less than a quarter of the vessel's breadth from the outer shell.

5.5.7.6 The shore connections are to be located not less than 6 [m] from the entrances to, or openings of, the accommodation and service spaces outside the cargo area.

5.5.7.7 Each shore connection of the venting piping and shore connections of the piping for loading and unloading, through which the loading or unloading operation is carried out, is to be fitted with a shut-off device. However, each shore connection is to be fitted with a blind flange when it is not in operation.

5.5.7.8 The flanges and stuffing boxes are to be provided with a spray protection device.

5.5.7.9 Piping for loading and unloading, and venting piping, are not to have flexible connections fitted with sliding seals.

5.5.7.10 The distance referred to in 5.5.7.1 and 5.5.7.6 may be reduced to 3 [m] if a transverse bulkhead complying with **Error! Reference ource not found.** is situated at the end of the cargo area. The openings are to be provided with doors. The following notice is to be displayed on the doors:

**DO NOT OPEN DURING LOADING AND UNLOADING WITHOUT PERMISSION.**

**CLOSE IMMEDIATELY.**

5.5.7.11 Every component of the piping for loading and unloading are to be electrically connected to the hull.

5.5.7.12 The piping for loading is to extend down to the bottom of the cargo tanks.

5.5.7.13 The stop valves or other shut-off devices of the piping for loading and unloading are to indicate whether they are open or shut.

5.5.7.14 The piping for loading and unloading is to have, at the test pressure, the required elasticity, leakproofness and resistance to pressure.

5.5.7.15 The piping for loading and unloading is to be fitted with pressure gauges at the outlet of the pumps. The permissible maximum overpressure or vacuum value is to be indicated on each measuring device. Readings are to be possible in all weather conditions.

5.5.7.16 When piping for loading and unloading are used for supplying the cargo tanks with washing or ballast water, the suctions of these pipes are to be located within the cargo area but outside the cargo tanks. Pumps for tank washing systems with associated connections may be located outside the cargo area, provided the discharge side of the system is arranged in such a way that the suction is not possible through that part. A spring-loaded non-return valve is to be provided to prevent any gases from being expelled from the cargo area through the tank washing system.

5.5.7.17 A non-return valve is to be fitted at the junction between the water suction pipe and the cargo loading pipe.

5.5.7.18 The permissible loading and unloading flows are to be calculated. Calculations concern the permissible maximum loading and unloading flow for each cargo tank or each group of cargo tanks, taking into account the design of the ventilation system. These calculations are to take into consideration the fact that in the event of an unforeseen cut–off of the vapour return piping of the shore facility, the safety devices of the cargo tanks will prevent pressure in the cargo tanks from exceeding the following values:

- over–pressure: 115% of the opening pressure of the high-velocity vent valve;
- vacuum pressure: not more than the construction vacuum pressure but not

exceeding 5 [kPa] (0.05 bar).

The main factors to be considered are the following:

a) Dimensions of the ventilation system of the cargo tanks;

b) Gas formation during loading: multiply the largest loading flow by a factor of not less than 1.25;

c) Density of the vapour mixture of the cargo based on 50% volume vapour and 50% volume air;

d) Loss of pressure through ventilation pipes, valves and fittings. Account will be taken of a 30% clogging of the mesh of the flame-arrester;

e) Chocking pressure of the safety valves.

The permissible maximum loading and unloading flows for each cargo tank or for each group of cargo tanks are to be given in an on-board instruction.

5.5.7.19 Compressed air generated outside the cargo area or wheelhouse can be used in the cargo area subject to the installation of a spring-loaded non-return valve to

ensure that no gases can escape from the cargo area through the compressed air system into accommodation or service spaces outside the cargo area.

5.5.7.20 If the vessel is carrying several dangerous substances liable to react dangerously with each other, a separate pump with its own piping for loading and unloading is to be installed for each substance. The piping is not to pass through a cargo tank containing dangerous substances with which the substance in question is liable to react.

5.5.8 Tanks and receptacles for residual products and receptacles for slops

5.5.8.1 If vessels are provided with a tank for residual products, it is to comply with the provisions of 5.5.8.3, 5.5.8.4, **Error! eference source not found.**, 5.5.8.6 and 5.5.8.7.Receptacles for residual products and receptacles for slops are to be located only in the cargo area. During the filling of the receptacles for residual products, means for collecting any leakage is to be placed under the filling connections.

5.5.8.2 Receptacles for slops are to be fire resistant and are to be capable of being closed with lids. The receptacles for slops are to be marked and be easy to handle.

5.5.8.3 The maximum capacity of a tank for residual products is 30 [$m^3$].

5.5.8.4 The tank for residual products is to be equipped with:

- pressure-relief and vacuum relief valves.

  The high velocity vent valve is to be so regulated as not to open during carriage. This condition is met when the opening pressure of the valve meets the conditions set out in column (10) of Table C of Chapter 3.2 of ADN; When anti-explosion protection is required in column (17) of Table C of Chapter 3.2 of ADN, the vacuum-relief valve is to be capable of withstanding deflagrations and the highvelocity vent valve is to withstand steady burning;

- a level indicator;
- connections with shut-off devices, for pipes and hose assemblies.

5.5.8.5 Receptacles for residual products are to be equipped with:

- a connection enabling gases released during filling to be evacuated safely;
- a possibility of indicating the degree of filling;
- connections with shut-off devices, for pipes and hose assemblies.

5.5.8.6 Receptacles for residual products are to be connected to the venting piping of cargo tanks only for the time necessary to fill them. During the filling of the receptacle, released gases are to be safely evacuated.

5.5.8.7 Receptacles for residual products and receptacles for slops placed on the deck are to be located at a minimum distance from the hull equal to one quarter of the vessel's breadth.

5.5.9 Requirements for Electrical Installations

5.5.9.1 Documents concerning electrical installations

5.5.9.1.1 In addition to the other required documentations, the following documents are to be on board:

a) a drawing indicating the boundaries of the cargo area and the location of the electrical equipment installed in this area;

b) a list of the electrical equipment referred to in (a) above including the following particulars: machine or appliance, location, type of protection, type of protection against explosion, testing body and approval number;

c) a list of or general plan indicating the electrical equipment outside the cargo area which may be operated during loading, unloading or gas-freeing. All other electrical equipment is to be marked in red. See 5.5.9.3.7 and 5.5.9.3.8.

5.5.9.2 Electrical installations

5.5.9.2.1 Only distribution systems without return connection to the hull are permitted.

This provision does not apply to:

- active cathodic corrosion protection;
- certain limited sections of the installations situated outside the cargo area (e.g. connections of starters of diesel engines);
- the device for checking the insulation level referred to in 5.5.9.2.2 below.

5.5.9.2.2 Every insulated distribution network is to be fitted with an automatic device with a visual and audible alarm for checking the insulation level.

5.5.9.2.3 For the selection of electrical equipment to be used in zones presenting an explosion risk, the explosion groups and temperature classes assigned to the substances carried in accordance with columns (15) and (16) of Table C of Chapter 3.2 of ADN is to be taken into consideration.

5.5.9.3 Type and location of electrical equipment

5.5.9.3.1 Only the following equipment may be installed in cargo tanks, residual cargo tanks, and piping for loading and unloading (comparable to zone 0):

- measuring, regulation and alarm devices of the EEx (ia) type of protection.

5.5.9.3.2 Only the following equipment may be installed in the cofferdams, double-hull spaces, double bottoms and hold spaces (comparable to zone 1):

- measuring, regulation and alarm devices of the certified safe type;
- lighting appliances of the “flame-proof enclosure” or “apparatus protected by pressurization” type of protection;
- hermetically sealed echo sounding devices the cables of which are led through thick-walled steel tubes with gastight connections up to the main deck;
- cables for the active cathodic protection of the shell plating in protective steel tubes such as those provided for echo sounding devices.

The following equipment may be installed only in double-hull spaces and double bottoms if used for ballasting:

- Permanently fixed submerged pumps with temperature monitoring, of the certified safe type.

5.5.9.3.3 Only the following equipment may be installed in the service spaces in the cargo area below deck (comparable to zone 1):

- measuring, regulation and alarm devices of the certified safe type;
- lighting appliances of the “flame-proof enclosure” or “apparatus protected by pressurization” type of protection;
- motors driving essential equipment such as ballast pumps with temperature monitoring; they are to be of the certified safe type.

5.5.9.3.4 The control and protective equipment of the electrical equipment referred to in paragraphs 5.5.9.3.1, 5.5.9.3.2 and 5.5.9.3.3 above is to be located outside the cargo area if they are not intrinsically safe.

5.5.9.3.5 The electrical equipment in the cargo area on deck (comparable to zone 1) is to be of the certified safe type.

5.5.9.3.6 Accumulators are to be located outside the cargo area.

5.5.9.3.7 Electrical equipment used during loading, unloading and gas-freeing during berthing and which are located outside the cargo area are to (comparable to zone 2) be at least of the “limited explosion risk” type.

5.5.9.3.7.1 This provision does not apply to:

a) lighting installations in the accommodation, except for switches near entrances to accommodation;

b) radiotelephone installations in the accommodation or the wheelhouse;

c) mobile and fixed telephone installations in the accommodation or the wheelhouse;

d) electrical installations in the accommodation, the wheelhouse or the service spaces outside the cargo areas if:

A. These spaces are fitted with a ventilation system ensuring an overpressure of 0.1 [kPa] (0.001 bar) and none of the windows is capable of being opened; the air intakes of the ventilation system are to be located as far away as possible, however, not less than 6 [m] from the cargo area and not less than 2 [m] above the deck;

B. The spaces are fitted with a gas detection system with sensors:

i. at the suction inlets of the ventilation system;

ii. directly at the top edge of the sill of the entrance doors of the accommodation and service spaces;

C. The gas concentration measurement is continuous;

D. When the gas concentration reaches 20% of the lower explosive limit, the ventilators are switched off. In such a case and when the overpressure is not maintained or in the event of failure of the gas detection system, the electrical installations which do not comply with 5.5.9.3.7 above, are to be switched off. These operations are to be performed immediately and automatically and activate the emergency lighting in the accommodation, the wheelhouse and the service spaces, which is to comply at least with the "limited explosion risk" type. The switching-off is to be indicated in the accommodation and

wheelhouse by visual and audible signals;

E. The ventilation system, the gas detection system and the alarm of the switch-off device fully comply with the requirements of 5.5.9.3.7 above;

F. The automatic switch-off device is set so that no automatic switching-off may occur while the vessel is under way.

e) Inland AIS (automatic identification systems) stations in the accommodation and in the wheelhouse if no part of an aerial for electronic apparatus is situated above the cargo area and if no part of a VHF antenna for AIS stations is situated within 2 [m] from the cargo area.

5.5.9.3.8 The electrical equipment which does not meet the requirements set out in 5.5.9.3.7 above together with its switches are to be marked in red. The disconnection of such equipment is to be operated from a centralised location on board.

5.5.9.3.9 An electric generator which is permanently driven by an engine and which does not meet the requirements of 5.5.9.3.7 above, is to be fitted with a switch capable of shutting down the excitation of the generator. A notice board with the operating instructions is to be displayed near the switch.

5.5.9.3.10 Sockets for the connection of signal lights and gangway lighting are to be permanently fitted to the vessel close to the signal mast or the gangway. Connecting and disconnecting is not to be possible except when the sockets are not live.

5.5.9.3.11 The failure of the power supply for the safety and control equipment is to be immediately indicated by visual and audible signals at the locations where the alarms are usually actuated.

5.5.9.4 Earthing

5.5.9.4.1 The metal parts of electrical appliances in the cargo area which are not live as well as protective metal tubes or metal sheaths of cables in normal service are to be earthed, unless they are so arranged that they are automatically earthed by bonding to the metal structure of the vessel.

5.5.9.4.2 The provisions of 5.5.9.4.1 above apply also to equipment having service voltages of less than 50 V.

5.5.9.4.3 Independent cargo tanks are to be earthed.

5.5.9.4.4 Receptacles for residual products are to be capable of being earthed.

5.5.9.5 Electrical cables

5.5.9.5.1 All cables in the cargo area are to have a metallic sheath.

5.5.9.5.2 Cables and sockets in the cargo area are to be protected against mechanical damage.

5.5.9.5.3 Movable cables are prohibited in the cargo area, except for intrinsically safe electric circuits or for the supply of signal lights, gangway lighting.

5.5.9.5.4 Cables of intrinsically safe circuits are only to be used for such circuits and are to be separated from other cables not intended for being used in such circuits (e.g. they are not to be installed together in the same string of cables and they are not to be fixed by the same cable clamps).

5.5.9.5.5 For movable cables intended for signal lights, gangway lighting, , only sheathed cables of type H 07 RN-F in accordance with IEC publication-60 245-4 (1994) or cables of at least equivalent design having conductors with a cross-section of not less than 1.5 [$mm^2$] is to be used. These cables are to be as short as possible and installed so that damage is not likely to occur.

5.5.9.5.6 The cables required for the electrical equipment referred to in 5.5.9.3.2 and 5.5.9.3.3 are accepted in cofferdams, double-hull spaces,

double bottoms, hold spaces and service spaces below deck. When the vessel is only authorized to carry substances for which no antiexplosion protection is required in column (17) of Table C in Chapter 3.2 of ADN, cable penetration is permitted in the hold spaces.

5.5.10 Inspection and Testing

5.5.10.1 Pressure tests

5.5.10.1.1 The cargo tanks, residual cargo tanks, cofferdams, piping for loading and unloading are to be subjected to initial tests before being put into service and thereafter at prescribed intervals. Where a heating system is provided inside the cargo tanks, the heating coils are to be subjected to initial tests before being put into service and thereafter at prescribed intervals.

5.5.10.1.2 The test pressure for the cargo tanks and residual cargo tanks is to be not less than 1.3 times the construction pressure. The test pressure for the cofferdams and open cargo tanks is to be not less than 10 [kPa] (0.10 bar) gauge pressure.

5.5.10.1.3 The test pressure for piping for loading and unloading is to be not less than 1000 [kPa] (10 bar) gauge pressure.

5.5.10.1.4 The maximum intervals for the periodic tests is to be 11 years.

5.5.10.1.5 The procedure for pressure test is to be approved.

**Vessels Carrying Dangerous Cargoes in Gaseous State**

**(Type G Vessels)**

**6.1 Application**

6.1.1 This section applies to propelled and non-propelled tankers of Types G, intended for the carriage of dangerous liquids of Class 2 in bulk.

**6.2 Documents to be Submitted**

6.2.1 Following plans and documents are to be submitted in addition to the documents required in the other parts of the rules for the parts of the vessel not affected by the cargo, as applicable.

6.2.1.1 For Approval

a) Gas-dangerous zones plan.

b) Location of void spaces and accesses to dangerous zones

c) Air locks between safe and dangerous zones.

d) Ventilation duct arrangement in gas-dangerous spaces and adjacent zones.

e) Details of hull structure in way of cargo tanks, including support arrangement for tanks, saddles, anti-floating and anti-lifting devices, deck sealing arrangements, etc.

f) Calculation of the hull temperature in all the design cargo conditions.

g) Intact and damage stability calculations.

h) Scantlings, material and arrangement of the cargo containment system.

i) Details of insulation.

j) Details of ladders, fittings and towers in tanks and relative stress analysis, if any.

k) Details of tank domes and deck sealings.

l) Plans and calculations of safety relief valves.

m) Details of cargo handling and vapour system, including arrangements and details of piping and fitting.

n) Details of cargo pumps and cargo compressors.

o) Details of process pressure vessels and relative valving arrangement.

p) Bilge and ballast system in cargo area.

q) Gas freeing system in cargo tanks including inert gas system.

r) Ventilation system in cargo area.

s) Refrigeration plant system diagram, if any.

t) Water spray system diagram.

u) Details of electrical equipment installed in cargo area, including the list of certified safe equipment and apparatus and electrical bonding of cargo tanks and piping.

v) Schematic electrical wiring diagram in cargo area.

w) Gas detection system.

x) Cargo tank instrumentation, including cargo and hull temperature monitoring system.

y) Emergency shutdown system.

z) Details of fire-extinguishing appliances and systems in cargo area.

aa) Arrangement drawing of the various fire bulkheads and decks with standard fire test reports for the various arrangements, surface coverings, paints and similar.

bb) Loading and unloading operation description, including cargo tank filling limits.

6.2.1.2 For Information

a) Design characteristics of products to be carried, including maximum density, maximum vapour pressure, maximum liquid temperature and other important design conditions.

b) General arrangement plan, showing location of cargo tanks and fuel oil, ballast and other tanks.

**6.3 Materials of Construction**

6.3.1 Materials and grades of steel are to comply with the requirements of Annex 1 requirements for Inspection and Testing of Materials and as required by the individual vessel type. The independent cargo tanks may also be constructed of other materials, provided these have at least equivalent properties and resistance against the effects of temperature and fire.

6.3.2 Every part of the vessel including any installation and equipment which may come into contact with the cargo is to consist of materials which can neither be dangerously affected by the cargo nor cause decomposition of the cargo or react with it so as to form harmful or hazardous products. In case this aspect has not been examined during inspection of the vessel a relevant reservation is to be entered in the list of cargoes .

6.3.3 The use of wood, aluminium alloys or plastic materials within the cargo area is not allowed, except where explicitly permitted as below or in the certificate of approval:

- The use of wood, aluminium alloys or plastic materials within the cargo area is only permitted for:
  - gangways and external ladders;
  - movable items of equipment;
  - chocking of cargo tanks which are independent of the vessel's hull and chocking of installations and equipment;
  - masts and similar round timber;
  - engine parts;
  - parts of the electrical installation;
  - lids of boxes which are placed on the deck.
- The use of wood or plastic materials within the cargo area is only permitted for:
  - supports and stops of any kind.
- The use of plastic materials or rubber within the cargo area is only permitted for:
  - all kinds of gaskets (e.g. for dome or hatch covers);
  - electric cables;
  - hose assemblies for loading and unloading;
  - insulation of cargo tanks and of piping for loading and unloading;
  - photo-optical copies of the certificate of approval.
- All permanently fitted material in the accommodation or wheelhouse, with the exception of furniture, is not to evolve fumes or toxic gases in dangerous quantities, if involved in a fire.

6.3.4 The paint used in the cargo area is not to be liable to produce sparks in case of impact.

6.3.5 The use of plastic materials for the vessel's boats is permitted only of the material does not readily ignite.

6.3.6 To avoid corrosive attack of the cargo tank structure by chemical cargoes, it is strongly recommended the structure be protected by suitable lining or coating.

6.3.7 The suitability of the lining or coating and its compatibility with the intended cargoes is the responsibility of the Builder and Owner. Designated Authority/Classification Society will require the confirmation of the manufacturer that the lining or coating used to protect the cargo tank structure is compatible with the cargoes mentioned in list of cargoes.

## 6.4 Requirements for Type G Vessel

### 6.4.1 General

6.4.1.1 Application

6.4.1.1.1 Requirements of this subsection are applicable to Type G tankers.

### 6.4.2 Arrangement

6.4.2.1 Protection against Penetration of Gases

6.4.2.1.1 The vessel is to be designed so as to prevent gases from penetrating into the accommodation and the service spaces.

6.4.2.1.2 Outside the cargo area, the lower edges of door-openings in the sidewalls of superstructures and the coaming of access hatches to under-deck spaces are to have a height of not less than 0.50 [m] above the deck. This requirement need not be complied with if the wall of the superstructures facing the cargo area extends from one side of the vessel to the other and has doors the sills of which have a height of not less than 0.50 [m]. The height of this wall is not to be less than 2 [m]. In this case, the lower edges of door-openings in the sidewalls of superstructures and the coamings of access hatches behind this wall are to have a height of not less than 0.10 [m]. The sills of engine room doors and the coamings of its access hatches are to, however, always have a height of not less than 0.50 [m].

6.4.2.1.3 In the cargo area, the lower edges of door-openings in the sidewalls of superstructures are to have a height of not less than 0.50 [m] above the deck and the sills of hatches and ventilation openings of premises located under the deck are to have a height of not less than 0.50 [m] above the deck. This requirement does not apply to access openings to double-hull and double bottom spaces.

6.4.2.1.4 The bulwarks, foot-rails, etc are to be provided with sufficiently large openings which are located directly above the deck.

6.4.2.2 Ventilation

6.4.2.2.1 Each hold space is to have two openings. The dimensions and location of these openings are to be such as to permit effective ventilation of any part of the hold space. If there are no such openings, it is to be possible to fill the hold spaces with inert gas or dry air.

6.4.2.2.2 Double-hull spaces and double bottoms within the cargo area which are not arranged for being filled with ballast water, hold spaces and cofferdams, are to be provided with ventilation systems.

6.4.2.2.3 Any service spaces located in the cargo area below deck are to be provided with a system of forced ventilation with sufficient power for ensuring at least 20 changes of air per hour based on the volume of the space.

6.4.2.2.4 The ventilation exhaust ducts are to be located up to 50 [mm] above the bottom of the service space. The air is to be supplied through a duct at the top of the service space. The air inlets are to be located not less than 2 [m] above the deck, at a distance of not less than 2[m] from tank openings and not less than 6 [m] from the outlets of safety valves. The extension pipes which may be necessary may be of the hinged type.

6.4.2.2.5 Ventilation of accommodation and service spaces is to be possible

6.4.2.2.6 Ventilators used in the cargo area are to be designed so that no sparks may be emitted on contact of the impeller blades with the housing and no static electricity may be generated.

6.4.2.2.7 Notice boards are to be fitted at the ventilation inlets indicating the conditions when they are to be closed. All ventilation inlets of accommodation and service spaces leading outside are to be fitted with fire flaps. Such ventilation inlets are to be located not less than 2 [m] from the cargo area. Ventilation inlets of service spaces in the cargo area may be located within such area.

6.4.2.3 Engine rooms

6.4.2.3.1 Internal combustion engines for the vessel's propulsion as well as internal combustion engines for auxiliary machinery are to be located outside the cargo area. Entrances and other openings of engine rooms are to be at a distance of not less than 2 [m] from the cargo area.

6.4.2.3.2 The engine rooms are to be accessible from the deck; the entrances are not to face the cargo area. The hinges are to face the cargo area when the doors are not located in a recess whose depth is at least equal to the door width.

6.4.2.4 Accommodation and Service Spaces

6.4.2.4.1 Accommodation spaces and the wheelhouse are to be located outside the cargo area forward of the fore vertical plane or abaft the aft vertical plane bounding the part of cargo area below deck. Windows of the wheelhouse which are located not less than 1 [m] above the bottom of the wheelhouse may tilt forward.

6.4.2.4.2 Entrances to spaces and openings of superstructures are not to face the cargo area. Doors opening outward and not located in a recess the depth of which is at least equal to the width of the doors are to have their hinges facing the cargo area.

6.4.2.4.3 Entrances from the deck and openings of spaces facing the weather are to be capable of being closed. The following instruction is to be displayed at the entrance of such spaces:

**"DO NOT OPEN DURING LOADING, UNLOADING OR GAS-FREEING WITHOUT PERMISSION.**

**CLOSE IMMEDIATELY."**

6.4.2.4.4 Entrances and windows of superstructures and accommodation spaces which can be opened as well as other openings of these spaces are to be located not less than 2 [m] from the cargo area. Wheelhouse doors and windows are not to be located within 2 [m] from the cargo area, except when there is no direct connection between the wheelhouse and the accommodation.

6.4.2.4.5 Penetrations

6.4.2.4.5.1 Driving shafts of the bilge or ballast pumps may penetrate through the bulkhead between the service space and the engine room, provided the arrangement of the service space is in compliance with 6.4.3.1.15, 6.4.3.1.16 and 6.4.3.1.17.

6.4.2.4.5.2 The penetration of the shaft through the bulkhead is to be gastight and is to be approved.

6.4.2.4.5.3 The necessary operating instructions are to be displayed.

6.4.2.4.5.4 Penetrations through the bulkhead between the engine room and the service space in the cargo area, and the bulkhead between the engine room and the hold spaces may be provided for electrical cables, hydraulic and piping for measuring, control and alarm systems, provided that the penetrations are approved. The penetrations are to be gastight. Penetrations through a bulkhead with an "A-60" fire protection insulation are to have an equivalent fire protection.

6.4.2.4.5.5 Pipes may penetrate the bulkhead between the engine room and the service space in the cargo area provided that these are pipes between the mechanical equipment in the engine room and the service space which do not have any openings within the service space and which are provided with shut-off devices at the bulkhead in the engine room.

6.4.2.4.5.6 Notwithstanding 6.4.3.1.13, pipes from the engine room may penetrate the service space in the cargo area or a cofferdam or a hold space or a double hull space to the outside provided that within the service space or cofferdam or hold space or double-hull space they are of the thick-walled type and have no flanges or openings.

6.4.2.4.5.7 Where a driving shaft of auxiliary machinery penetrates through a wall located above the deck the penetration is to be gastight.

6.4.2.4.6 A service space located within the cargo area below deck is not to be used as a cargo pump room for the vessel's own gas discharging system, e.g. compressors or the compressor/ heat exchanger/ pump combination, except where:

- the pump-room is separated from the engine room or from service

spaces outside the cargo area by a cofferdam or a bulkhead with an "A-60" fire protection insulation or by a service space or a hold space;

- the "A-60" bulkhead required above does not include penetrations referred to in 6.4.2.4.5.1;
- ventilation exhaust outlets are located not less than 6.0 [m] from entrances and openings of the accommodation and service spaces outside the cargo area;
- the access hatches and ventilation inlets can be closed from the outside;
- all piping for loading and unloading (at the suction side and delivery side) are led throught the deck above the pump room. The necessary operation of the control devices in the pump room, starting of pumps or compressors and necessary control of the liquid flow rate is to be effected from the deck;
- the system is fully integrated in the gas and liquid piping system;
- the cargo pump room is provided with a permanent gas detection system which automatically indicates the presence of explosive gases or lack of oxygen by means of direct-measuring sensors and which actuates a visual and audible alarm when the gas concentration has reached 20% of the lower explosive limit. The sensors of this system are to be placed at suitable positions at the bottom and directly below the deck. Measurement is to be continuous. The audible and visual alarms are installed in the wheelhouse and in the cargo pump room and, when the alarm is actuated, the loading and unloading system is shut down. Failure of the gas detection system is to be immediately signalled in the wheelhouse and on deck by means of audible and visual alarms;
- the ventilation system prescribed in 6.4.2.2.3 has a capacity of not less than 30 changes of air per hour based on the total volume of the service space.

6.4.2.4.7 The following instruction is to be displayed at the entrance of the cargo pump room:

**"BEFORE ENTERING THE CARGO PUMP-ROOM CHECK WHETHER IT IS FREE FROM GASES AND CONTAINS SUFFICIENT OXYGEN.**

**DO NOT OPEN DOORS AND ENTRANCE OPENINGS WITHOUT PERMISSION.**

**LEAVE IMMEDIATELY IN EVENT OF ALARM."**

6.4.2.5 Inerting Facility

6.4.2.5.1 In cases in which inerting or blanketing of the cargo is prescribed, the vessel is to be equipped with an inerting system.

6.4.2.5.2 This system is to be capable of maintaining a permanent minimum pressure of 7 [kPa] (0.07 bar) in the spaces to be inerted. In addition, the inerting system is not to increase the pressure in the cargo tank to a pressure greater than that at which the pressure valve is regulated. The set pressure of the vacuum-relief valve is to be 3.5 [kPa] (0.035 bar).

6.4.2.5.3 A sufficient quantity of inert gas for loading or unloading is to be carried or produced on board if it is not possible to obtain it on shore. In addition, a sufficient quantity of inert gas to offset normal losses occurring during carriage is to be on board.

6.4.2.5.4 The premises to be inerted are to be equipped with connections for introducing the inert gas and monitoring systems so as to ensure the correct atmosphere on a permanent basis.

6.4.2.5.5 When the pressure or the concentration of inert gas in the gaseous phase falls below a given value, this monitoring system is to activate an audible and visible alarm in the wheelhouse. When the wheelhouse is unoccupied, the alarm is also to be audible in a location occupied by a crew member.

6.4.2.6 Engines

6.4.2.6.1 Only internal combustion engines running on fuel with a flashpoint of more than 55 [°C] are allowed. This provision does not apply to internal combustion engines which are part of propulsion and auxiliary systems. These systems are to meet the requirements of Designated Authority/ Classification Society.

6.4.2.6.2 Ventilation inlets of the engine room and, when the engines do not take in air directly from the engine room, the air intakes of the engines are to be located not less than 2 [m] from the cargo area.

6.4.2.6.3 Sparking is not to be possible within the cargo area.

6.4.2.6.4 The surface temperature of the outer parts of engines used during loading or unloading operations, as well as that of their air inlets and exhaust ducts are not to exceed the allowable temperature according to the temperature class of the substances carried. This provision does not apply to engines installed in service spaces provided the provisions of 6.4.8.3.7 are fully complied with.

6.4.2.6.5 The ventilation in the closed engine room is to be designed so that, at an ambient temperature of 20 [°C], the average temperature in the engine room does not exceed 40 [°C].

6.4.2.7 Oil Fuel Tanks

6.4.2.7.1 When the vessel is fitted with hold spaces and double bottoms, double bottoms within the cargo area may be arranged as oil fuel tanks, provided their depth is not less than 0.6 [m]. Oil fuel pipes and openings of such tanks are not permitted in the hold space.

6.4.2.7.2 Open ends of air pipes of all oil fuel tanks are to extend to not less than 0.5 [m] above the open deck. The open ends and the open ends of overflow pipes leading to the deck are to be fitted with a protective device consisting of a gauze diaphragm or a perforated plate.

6.4.2.8 Exhaust Pipes

6.4.2.8.1 Exhausts are to be evacuated from the vessel into the open air either upwards through an exhaust pipe or through the shell plating. The exhaust outlet is to be located not less than 2 [m] from the cargo area. The exhaust pipes of engines are to be arranged so that the exhausts are led away from the vessel. The exhaust pipes are not to be located within the cargo area.

6.4.2.8.2 Exhaust pipes of engines are to be provided with a device preventing the escape of sparks, e.g. spark arresters.

6.4.2.9 Bilge Pumping and Ballasting Arrangements

6.4.2.9.1 Bilge and ballast pumps for spaces within the cargo area are to be installed within such area. This provision does not apply to:

- double-hull spaces and double bottoms which do not have a common boundary wall with the cargo tanks;
- cofferdams and hold spaces where ballasting is carried out using the piping of the fire-fighting system in the cargo area and bilge–pumping is performed using eductors.

6.4.2.9.2 Where the double bottom is used as a liquid oil fuel tank, it is not to be connected to the bilge piping system.

6.4.2.9.3 Where the ballast pump is installed in the cargo area, the standpipe and its outboard connection for suction of ballast water is to be located within the cargo area.

6.4.2.9.4 It is to be possible for an under-deck pump-room to be

stripped in an emergency using a system located in the cargo area and independent of any other system. This stripping system is to be located outside the pump-room.

6.4.3 Cargo Containment

6.4.3.1 Hold Spaces and Cargo Tanks

6.4.3.1.1 The maximum permissible capacity of a cargo tank is to be determined in accordance with Table 6.

where

**Table 6: Tank Sizes**

| $L_{OA}$ x $B_{OA}$ x H (m$^3$) | Maximum permissible capacity of a cargo tank (m$^3$) |
|---|---|
| < 600 | $L_{OA}$ x $B_{OA}$ x $H$ x 0.3 |
| 600 to 3750 | 180 + ($L_{OA}$ x $B_{OA}$ x H – 600) x 0.0635 |
| > 3750 | 380 |

$L_{OA}$ X $B_{OA}$ X H : Product of the tank vessel main dimensions, in m, where :

$L_{OA}$ : overall length of the hull, in m;

$B_{OA}$: Extreme breadth of the hull, in m;

H : Shortest vertical distance between the top of the keel and the lowest point of the deck at the side of the vessel (moulded depth) within the cargo area in m;

where

In the case of trunk deck vessels, H' is to be substituted for H. H' is to be determined by the following formula:

$$\boldsymbol{H' = H + \left(h_t \times \frac{b_t}{B} \times \frac{l_t}{L}\right)}$$

Where,

ht: Height, in m, of trunk (distance between trunk deck and main deck on trunk side measured at L/2)

bt : Trunk breadth, in [m]

lt : Trunk length, in [m]

6.4.3.1.2 Alternative constructions in accordance with Chapter 9, 9.3.4 of ADN are acceptable.

6.4.3.1.3 Length to diameter ratio of pressure tanks is not to exceed 7.

6.4.3.1.4 The pressure tanks are to be designed for a cargo temperature of + 40 [°C].

6.4.3.1.5 In the cargo area, the vessel is to be designed as follows Note 1) :

6.4.3.1.5.1 As a double bottom-hull and double bottom vessel:

6.4.3.1.5.1.1 The internal distance between the side platings of the vessel and the longitudinal bulkheads is not to be less than 0.80 [m],

6.4.3.1.5.1.2 The height of the double bottom is not to be less than 0.60 [m],

6.4.3.1.5.1.3 The cargo tanks are to be supported by saddles extending between the tanks to not less than 20° below the horizontal centreline of the cargo tanks.

6.4.3.1.5.1.4 Refrigerated cargo tanks and cargo tanks used for the transport of refrigerated liquefied gases are to be installed only in hold spaces bounded by double-hull spaces and double-bottom. Cargo tank fastenings are to meet the requirements of Designated

Authority/Classification Society (See 3.6.4).

6.4.3.1.5.2 As a single-hull vessel:

6.4.3.1.5.2.1 With the side platings of the vessel between gangboard and top of floor plates provided with side stringers at regular intervals of not more than 0.60 [m] which are supported by web frames spaced at intervals of not more than 2 [m];

6.4.3.1.5.2.2 The side stringers and the web frames are to have a height of not less than 10% of the depth, however, not less than 0.30 [m];

6.4.3.1.5.2.3 The side stringers and web frames are to be fitted with a face plate made of flat steel and having a cross-section of not less than that of 7.5 [$cm^2$] and 15 [$cm^2$], respectively;

6.4.3.1.5.2.4 The distance between the sideplating of the vessel and the cargo tanks are to be not less than 0.80 [m]and between the bottom and the cargo tanks not less than 0.60 [m]. The depth below the suction wells may be reduced to 0.50 [m];

6.4.3.1.5.2.5 The lateral distance between the suction well of the cargo tanks and the bottom structure is to be not less than 0.10 [m];

6.4.3.1.5.2.6 The cargo tank supports and fastenings are to extend not less than 10° below the horizontal centreline of the cargo tanks.

Note 1) : Alternatively, for a different design of the hull in the cargo area, proof is to be submitted by way of calculations that in the event of a lateral collision with another vessel having a straight bow, an energy of 22 [MJ] can be absorbed without any rupture of the cargo tanks and the piping leading to the cargo tanks. Alternative construction in accordance with Chapter 9, 9.3.4 of ADN are acceptable.

6.4.3.1.6 The cargo tanks are to be fixed so that they cannot float.

6.4.3.1.7 The capacity of suction well is to be limited to not more than 0.10 [$m^3$]. For pressure cargo tanks, however, the capacity of a suction well may be of 0.20 [$m^3$].

6.4.3.1.8 Side-struts linking or supporting the load-bearing components of the sides of the vessel with the load-bearing components of the longitudinal walls of cargo tanks and side-struts linking the load-bearing components of the vessel's bottom with the tank bottom are not to be provided.

6.4.3.1.9 Cargo tanks intended to contain products at a temperature below -10 [°C] are to be suitably

insulated to ensure that the temperature of the vessel's structure does not fall below the minimum allowable design temperature. The insulation material is to be resistant to flame spread.

6.4.3.1.10 The hold spaces are to be separated from the accommodation, engine rooms and service spaces outside the cargo area below deck by bulkheads provided with a Class A-60 fire protection insulation. A space of not less than 0.20 [m] is to be provided between the cargo tanks and the tank bulkheads of the tank spaces. Where the cargo holds have plane end bulkheads, this space is not to be less than 0.50[m].

6.4.3.1.11 The hold spaces and cargo tanks are to be capable of being supported.

6.4.3.1.12 All spaces in the cargo region are to be capable of being ventilated. Means for checking their gas free condition are to be provided.

6.4.3.1.13 The bulkheads bounding the cargo tanks, cofferdams and hold spaces are to be watertight. The cargo tanks and the bulkheads bounding the cargo area are to have no openings or penetrations below deck. The bulkhead between the engine room and the service spaces within the cargo area or between the engine room and a hold space may be fitted with penetrations provided that they conform to the provisions of 6.4.2.4.5

6.4.3.1.14 Double-hull spaces and double bottoms in the cargo area are to be arranged for being filled with ballast water only. Double bottoms may, however, be used as fuel tanks, provided they comply with the requirements of 6.4.2.7.

6.4.3.1.15 A space in the cargo area below deck may be arranged as a service space, provided that the bulkhead bounding the service space extends vertically to the bottom and the bulkhead not facing the cargo area extends from one side of the vessel to the other in one frame plane. This service space is only to be accessible from the deck.

6.4.3.1.16 The service space is to be watertight with the exception of its access hatches and ventilation inlets.

6.4.3.1.17 No piping for loading or unloading is to be fitted within the service space referred to in 6.4.3.1.15 above. Piping for loading and unloading may be fitted in the cargo pump rooms below deck only when they comply with the requirements in 6.4.2.4.6

6.4.3.1.18 Where service spaces are located in the cargo area under deck, they are to be arranged so as to be easily accessible and to permit persons wearing protective clothing and breathing apparatus to safely operate the service equipment contained therein. They are to be designed so as to allow injured or unconscious personnel to be removed from such spaces without difficulty, if necessary by means of fixed equipment.

6.4.3.1.19 Hold spaces and other accessible spaces within the cargo area are to be arranged so that they may be completely inspected and cleaned in an appropriate manner. The dimensions of openings except for those of double hull spaces and double bottoms which do not have a wall adjoining the cargo tanks are to be sufficient to allow a person wearing breathing apparatus to enter or leave the space without difficulty. These openings are to have a minimum cross-sectional area of 0.36 [$m^2$] and a minimum side length of 0.50 [m]. They are to be designed so as to allow an injured or unconscious person to be removed from the bottom of such a space without difficulties, if necessary by means of fixed equipment. In these spaces the distance between the reinforcements is not to be less than 0.50 [m]. In double bottoms this distance may be reduced to 0.45 [m]. Cargo tanks may have circular openings with a diameter of not less than 0.68 [m].

6.4.3.1.20 In case the vessel has insulated cargo tanks, the hold spaces are to only contain dry air to protect the insulation of the cargo tanks against moisture.

6.4.3.2 Cargo Tank Openings

6.4.3.2.1 Cargo tank openings are to be located on deck in the cargo area. Cargo tank openings with a cross-section greater than 0.10 [$m^2$] are to be located not less than 0.50 [m] above the deck.

6.4.3.2.2 Cargo tank openings are to be fitted with gastight closures which comply with the provisions of 6.4.9.1.1.

6.4.3.2.3 The exhaust outlets of the pressure relief valves are to be located not less than 2 [m] above the deck at a distance of not less than 6 [m] from the accommodation and from the service spaces located outside the cargo area. This height may be reduced when within a radius of 1 [m] round the pressure relief valve outlet there is no equipment, no work is being carried out and signs indicate the area.

6.4.3.2.4 The closing devices normally used in loading and unloading operations is not to be capable of producing sparks when operated.

6.4.3.2.5 Each tank in which refrigerated substances are carried is to be equipped with a safety system to prevent unauthorized vacuum or overpressure.

6.4.4 Stability

6.4.4.1 General

6.4.4.1.1 Proof of sufficient stability is to be submitted including stability in damaged condition.

6.4.4.1.2 The basic value for the stability calculation, the vessel's lightweight and location of centre of gravity, is to be determined wither by means of an inclining experiment or by detailed mass and moment calculation. In latter case the light weight of the vessel is to be checked by means of a light weight test with a tolerance limit of ±5% between the mass determined by calculation and the displacement determined by the draught readings.

6.4.4.1.3 Proof of sufficient intact stability is to be submitted for all stages of loading and unloading and for the final loading condition for all the relative densities of the substances transported contained in the list of cargoes. For every loading operation, taking account of the actual fillings and floating position of cargo tanks, ballast tanks and compartment, drinking water and sewage tanks and tanks containing products for the operation of the vessel, the vessel is to comply with the intact and damage stability requirements. Intermediate stages during operations are also to be taken into consideration. The proof of sufficient stability is to be shown for every operating, loading and ballast condition in the stability booklet, to be approved. If it is unpractical to pre-calculate the operating, loading and ballast conditions, an approved loading instrument is to be installed and used which contains the contents of the stability booklet.

6.4.4.1.4 Floatability after damage is to be proved for the most unfavorable loading condition. For this purpose, calculated proof of sufficient stability is to be established for critical intermediate stages of flooding and for the final stage of flooding.

6.4.4.2 Intact Stability

6.4.4.2.1 The requirements for intact stability resulting from the damage stability calculation is to be fully complied with.

6.4.4.2.2 For vessels with cargo tanks of more than 0.7B in width, proof is to be submitted that the following stability requirements have been complied with:

a) In the positive area of the righting lever curve up to immersion of the first non-watertight opening, righting lever(GZ) is not to be less than 0.1 [m]

b) The surface of the positive area of the righting lever curve up to immersion of the first non-watertight opening and in any event up to an angle of heel ≤27° is not to be less than 0.024 [m rad]

c) The metacentric height (GM) is not to be less than 0.1 [m]

These conditions are to be met bearing in mind the influence of all free surface in tanks for all stages of loading and

unloading.

6.4.4.2.3 The more stringent requirement of 6.4.4.2.1 and 6.4.4.2.2 is to be applied to the vessel.

6.4.4.3 Damage Stability

6.4.4.3.1 the following assumptions are to be taken into consideration for the damaged condition.

a) extent of side damage:

| | |
|---|---|
| Longitudinal extent : | At least 0.10 L, but not less than 5 [m] |
| Transverse extent : | 0.79 [m] inboard from the vessel's side at right angles to the centerline at the level corresponding to the maximum draught, or when applicable, the distance allowed by sec Chapter 9, 9.3.4 of ADN, reduced by 0.01[m] |
| Vertical extent : | From the base line upwards without limit |

b) extent of bottom damage:

| | |
|---|---|
| Longitudinal extent : | At least 0.10 L, but not less than 5 [m] |
| Transverse extent : | 3 [m] |
| Vertical extent : | From the base 0.59[m] upwards, the well excepted |

c) Any bulkhead within the damaged area is to be assumed damaged, which means that the location of bulkheads is to be chosen to ensure that the vessel remains afloat after the flooding of two or more adjacent compartments in the longitudinal direction.

The following provisions are applicable:

- For bottom damage, adjacent athwartship compartments are also to be assumed flooded;
- the lower edge of any non-watertight opening (e.g. windows, doors and access hatchways), at the final stage of flooding, is to be not less than 0.10 [m] above the damage waterline;
- In general, permeability is to be assumed to be 95%. Where an average permeability of less than 95% is calculated for any compartment, this calculated value obtained may be used. However, minimum values of permeability, μ, given in Table below are to be used. For the main engine room, only the one-compartment standard need be taken into account, i.e. the end bulkheads of the engine room are to be assumed as not damaged.

| | |
|---|---|
| Engine Room | 85% |
| Accommodation | 95% |
| Double Bottom, Oil Fuel Tanks, Ballast Tanks, etc. depending on whether, according to their function, they have to be assumed as full or empty for vessel floating at the maximum permissible draft | 0% or 95% |

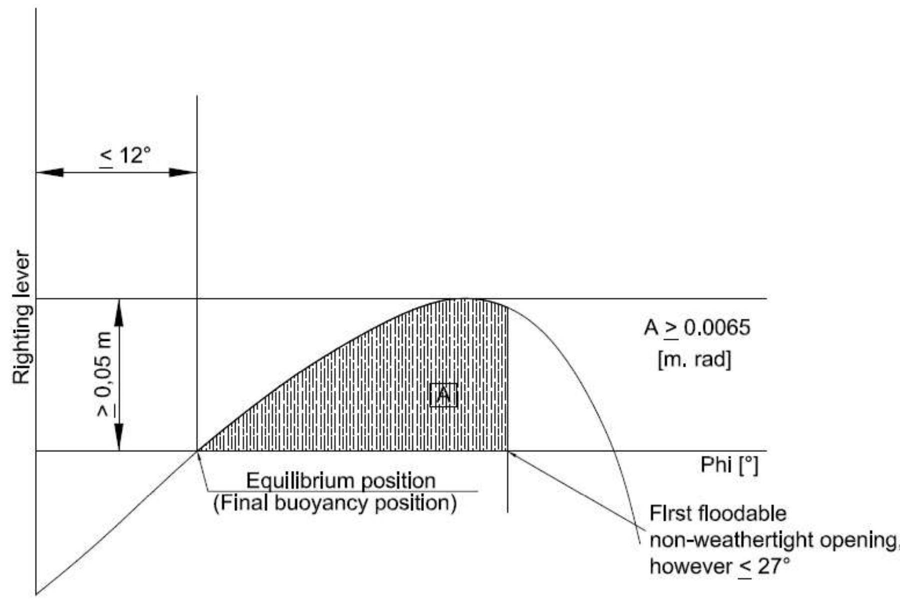
6.4.4.3.2 For the intermediate stage of flooding the following criteria have to be fulfilled:

GZ≥0.03[m]

Range of positive GZ: 5°

6.4.4.3.3 At the stage of equilibrium (in the final stage of flooding), the angle of heel is not to exceed 12°. Non-watertight openings are not to be flooded before reaching the stage of equilibrium. If such openings are immersed before the stage of equilibrium, the corresponding spaces are to be considered flooded for the purpose of stability calculation.

6.4.4.3.4 The positive range of the righting lever curve beyond the stage of equilibrium is to have a righting lever of ≥ 0.05 [m] in association with an area under the curve of ≥ 0.0065 [m.rad]. The minimum values of stability are to be satisfied up to immersion of the first non-weathertight openings and in any event up to an angle of heel ≤ 27°. If non-watertight openings are immersed before that stage, the corresponding spaces are to be considered flooded for the purpose of stability calculation.




6.4.4.3.5 If openings through which undamaged compartments may additionally become flooded are capable of being closed watertight, the closing appliances are to be marked accordingly.

6.4.4.3.6 Where cross- or down-flooding openings are provided for reduction of unsymmetrical flooding, the time of equalization is not to exceed 15 min, provided during the intermediate stages of flooding sufficient stability has been proved.

6.4.5 Safety and Control Installations

6.4.5.1 Cargo tanks are to be provided with the following equipment:

a) a level gauge;

b) a level alarm device which is activated at the latest when a degree of filling of 86% is reached;

c) a high level sensor for actuating the facility against overflowing when a degree of filling of 97.5% is reached;

d) an instrument for measuring the pressure of the gas phase inside the cargo tank;

e) an instrument for measuring the temperature of the cargo;

f) a connection for a closed-type sampling device.

6.4.5.2 When the degree of filling in percent is determined, an error of not more than 0.5% is permitted. It is to be calculated on the basis of the total cargo tank capacity including the expansion trunk.

6.4.5.3 The level gauge is to allow readings from the control position of the shut-off devices of the particular cargo tank. The permissible maximum filling level of 91%, 95% and 97%, as given in list of substances is to be marked on each level gauge. Permanent reading of the overpressure and vacuum is to be possible from a location from which loading or unloading operations may be interrupted. The permissible maximum overpressure and vacuum is to be marked on each level gauge. Readings are to be possible in all weather conditions.

6.4.5.4 The level alarm device is to give a visual and audible warning on board when actuated. The level alarm device is to be independent of the level gauge.

6.4.5.5 High Level Sensor

6.4.5.5.1 The high level sensor referred in 6.4.5.1 c) above is to give a visual and audible alarm on board and at the same time actuate an electrical contact which in the form of a binary signal interrupts the electric current loop provided and fed by the shore facility against overflowing during loading operations. The signal is to be transmitted to the shore facility via a watertight two-pin lug of a connecter device in accordance with IEC 60309 for direct current of 40 to 50 volts, identification color white, position of the nose 10 h. The plug is to be permanently fitted to the vessel close to the shore connections of the loading and unloading piping.

6.4.5.5.2 The high level sensor is also to be capable of switching off the vessel's own discharging pump.

6.4.5.5.3 The high level sensor is to be independent of the level alarm device, but it may be connected to the level gauge.

6.4.5.5.4 During discharging by means of the on-board pump, it is to be possible for the shore facility to switch it off. For this purpose, an independent intrinsically safe power line, fed by the vessel, is to be switched off by the shore facility by means of an electrical contact. The signal is to be transmitted via arrangements as indicated in 6.4.5.5.1 above. The socket is to be permanently fitted to the vessel close to the shore connections of the loading and unloading piping.

6.4.5.6 The visual and audible signals given by the level alarm device are to be clearly distinguishable from those of the high level sensor. The visual alarm is to be visible at each control position on deck of the cargo tank stop valves. It is to be possible to easily check the functioning of the sensors and electric circuits or these are to be of the "fail safe" design.

6.4.5.7 When the pressure or the temperature exceeds a set value, the instruments for measuring the pressure and temperature of the cargo is to activate an audible and visible alarm in the wheelhouse. When the wheelhouse is unoccupied, the alarm is also to be audible in a location occupied by a crew member.

6.4.5.8 When the pressure exceeds a set value during loading or unloading, the instrument for measuring the pressure is to simultaneously initiate an electrical contact which, by means of the plug referred to in **Error! Reference ource not found.** above, enables measures to be taken to interrupt the loading and unloading operation. If the vessel's own discharge pump is used, it is to be switched off automatically. The sensors for the alarms referred to above may be connected to the alarm installation.

6.4.5.9 When the control elements of the shut-off devices of the cargo tanks are located in a control room, it is to be possible to stop the loading pumps and read the level gauges in the control room, and the visual and audible warning given by the level alarm device, the high level sensor referred to in 6.4.5.1 c) and the instruments for measuring the pressure and temperature of the cargo is to be noticeable in the control room and on deck. Satisfactory monitoring of the cargo is to be ensured from the control room.

6.4.5.10 The vessel is to be so equipped that loading or unloading operations can be interrupted by means of switches, i.e. the quick-action stop valve located on the flexible vessel-to-shore connecting line is to be capable of being closed. The switches are to be placed at two pints on the vessel (fore and aft). The interruption systems are to be designed according to the quiescent current principle.

6.4.5.11 When refrigerated substances are carried the opening pressure of the safety

system is to be determined by the design of the cargo tanks. In the event of the transport of the substances that are to be carried in a refrigerated state the opening pressure of the safety system is not to be less than 25 [kPa] greater than the maximum pressure calculated according to 6.4.6.2

6.4.5.12 On vessels certified to carry refrigerated liquefied gases the following protective measures are to be provided in the cargo area:

6.4.5.12.1 Drip trays are to be installed under the shore connections of the piping for loading and unloading through which the loading and unloading operation is to be carried out. They are to be made of materials which are able to resist the temperature of the cargo and be insulated from the deck. The drip trays are to have a sufficient volume and an overboard drain.

6.4.5.12.2 A water spray system to cover:

- exposed cargo tank domes and exposed parts of cargo tanks;
- exposed on-deck storage vessels for flammable or toxic products;
- parts of the cargo deck area where a leakage may occur.

The capacity of the water spray system is to be such that when all spray nozzles are in operation, the outflow is of 300 [lit/m$^2$] of cargo deck area per hour. The system is to be capable of being put into operation from the wheelhouse and from the deck;

6.4.5.12.3 A water film around the shore connection of the piping for loading and unloading in use to protect the deck and the shipside in way of the shore connection of the piping for loading and unloading in use during connecting and disconnecting the loading arm or hose. The water film is to have sufficient capacity. The system is to be capable of being put into operation from the wheel house and from the deck.

6.4.5.13 Vessels carrying refrigerated liquefied gases are to have on board, for the purpose of preventing damage to the cargo tanks during loading and unloading, a written instruction for pre-cooling. This instruction is to be applied before the vessel is put into operation and after long term maintenance.

6.4.6 Cargo Pressure and Temperature Control

6.4.6.1 Requirements for maintenance of cargo pressure and temperature

6.4.6.1.1 Unless the entire cargo system is designed to resist the full effective vapour pressure of the cargo at the upper limits of the ambient design temperatures, the pressure of the tanks is to be kept below the permissible maximum set pressure of the safety valves, by one or more of the following means:

a) a system for the regulation of cargo tank pressure using mechanical refrigeration;

b) a system ensuring safety in the event of the heating or increase in pressure of the cargo. The insulation or the design pressure of the cargo tank, or the combination of these two elements, is to be such as to leave an adequate margin for the operating period and the temperatures expected; in each case the system is to be acceptable by Designated Authority/Classification Authority and is to ensure safety for a minimum time of three times the operation period;

c) when the LNG is used as fuel, a system for the regulation of cargo tank pressure whereby the boil-off vapours are utilized as fuel;

d) any other system, subject to special consideration

6.4.6.1.2 The systems prescribed in 6.4.6.1.1 are to be constructed,

installed and tested to the satisfaction of Designated Authority/Classification Society. The materials used in their construction are to be compatible with the cargoes to be carried. For normal service, the upper ambient design temperature limits are:

air: +45° C;

water: +32° C.

6.4.6.1.3 The cargo storage system is to be capable of resisting the full vapour pressure of the cargo at the upper limits of the ambient design temperatures, whatever the system adopted to deal with the boil-off gas. This requirement is indicated by the remark 37 in column (20) of Table C of Chapter 3.2 of ADN.

6.4.6.2 Refrigeration System

6.4.6.2.1 The refrigeration system referred to in 6.4.6.1.1 a) is to be composed of one or more units capable of keeping the pressure and temperature of the cargo at the upper limits of the ambient design temperatures at the prescribed level. Unless another means of regulating cargo pressure and temperature deemed satisfactory by a recognized classification society/Designated Authority is provided, provision is to be made for one or more stand-by units with an output at least equal to that of the largest prescribed unit. A stand-by unit is to include a compressor, its engine, its control system and all necessary accessories to enable it to operate independently of the units normally used. Provision is to be made for a stand-by heat-exchanger unless the system's normal heat-exchanger has a surplus capacity equal to at least 25% of the largest prescribed capacity. It is not necessary to make provision for separate piping. Cargo tanks, piping and accessories are to be insulated so that, in the event of a failure of all cargo refrigeration systems, the entire cargo remains for at least 52 hours in a condition not causing the safety valves to open.

6.4.6.2.2 The security devices and the connecting lines from the refrigeration system are to be connected to the cargo tanks above the liquid phase of the cargo when the tanks are filled to their maximum permissible degree of filling. They are to remain within the gaseous phase, even if the vessel has a list up to 12 degrees.

6.4.6.2.3 When several refrigerated cargoes with a potentially dangerous chemical reaction are carried simultaneously, particular care is to be given to the refrigeration systems so as to prevent any mixing of the cargoes. For the carriage of such cargoes, separate refrigeration systems, each including the full stand-by unit referred to in **Error! Reference ource not found.**, are to be provided for each cargo. When, however, refrigeration is ensured by an indirect or combined system and no leak in the heat exchangers can under any foreseeable circumstances lead to the mixing of cargoes, no provision need be made for separate refrigeration units for the different cargoes.

6.4.6.2.4 When several refrigerated cargoes are not soluble in each other under conditions of carriage such that their vapour pressures are added together in the event of mixing, particular care is to be given to the refrigeration systems to prevent any mixing of the cargoes.

6.4.6.2.5 When the refrigeration systems require water for cooling, a sufficient quantity is to be supplied by a pump or pumps used exclusively for the purpose. This pump or pumps are to have at least two suction pipes, leading from two water intakes, one to port, the other to starboard. Provision is to be made for a stand-by pump with a satisfactory flow; this may be a pump used for other purposes provided that its use for supplying water for cooling does not impair any other essential service.

6.4.6.2.6 The refrigeration system may take one of the following forms:

a) Direct system: the cargo vapours are compressed, condensed and returned

to the cargo tanks. This system is not to be used for certain cargoes specified in Table C of Chapter 3.2 of ADN. This requirement is indicated by remark 35 in column (20) of Table C of Chapter 3.2 of ADN;

b) Indirect system: the cargo or the cargo vapours are cooled or condensed by means of a coolant without being compressed;

c) Combined system: the cargo vapours are compressed and condensed in a cargo/coolant heat-exchanger and returned to the cargo tanks. This system is not to be used for certain cargoes specified in Table C of Chapter 3.2 of ADN. This requirement is indicated by remark 36 in column (20) of Table C of Chapter 3.2 of ADN.

6.4.6.2.7 All primary and secondary coolant fluids are to be compatible with each other and with the cargo with which they may come into contact. Heat exchange may take place either at a distance from the cargo tank, or by using cooling coils attached to the inside or the outside of the cargo tank.

6.4.6.2.8 When the refrigeration system is installed in a separate service space, this service space is to meet the requirements of 6.4.2.4.6.

6.4.6.2.9 For all cargo systems, the heat transmission coefficient as used for the determination of the holding time are to be determined by calculation. Upon completion of the vessel, the correctness of the calculation is to be checked by means of a heat balance test. The calculation and test is to be performed under supervision of Designated Authority/Classification Society. The heat transmission coefficient is to be documented and kept on board. The heat transmission coefficient is to be verified at every renewal of the certificate of approval.

6.4.6.3 Water Spray System

6.4.6.3.1 When water-spraying is required in column (9) of Table C of Chapter 3.2 of ADN a water-spray system is to be installed in the cargo area on deck for the purpose of reducing gases given off by the cargo by spraying water. The system is to be fitted with a connection device for supply from the shore. The spray nozzles are to be so installed that released gases are precipitated safely. The system is to be capable of being put into operation from the wheelhouse and from the deck. The capacity of the water-spray system is to be such that when all the spray nozzles are in operation, the outflow is of 50 [lit/m$^2$] of cargo deck area and per hour.

6.4.7 Pumps and Piping

6.4.7.1 Pumps, compressors and accessory loading and unloading piping are to be placed in the cargo area. Cargo pumps and compressors are to be capable of being shut down from the cargo area and, in addition, from a position outside the cargo area. Cargo pumps and compressors situated on deck are to be located not less than 6 [m] from entrances to, or openings of, the accommodation and service spaces outside the cargo area.

6.4.7.2 Piping

6.4.7.2.1 Piping for loading and unloading is to be independent of any other piping of the vessel. No cargo piping is to be located below deck, except those inside the cargo tanks and in the service spaces intended for the installation of the vessel's own gas discharging system.

6.4.7.2.2 Piping for loading and unloading is to be clearly distinguishable from other piping, e.g. by means of colour marking.

6.4.7.2.3 The piping for loading and unloading on deck, the venting piping with the exception of the shore connections but including the safety valves, and the valves are to be located within the longitudinal line formed by the outer boundaries

of the domes and not less than one quarter of the vessel's breadth from the outer shell. This requirement does not apply to the relief pipes situated behind the safety valves. If there is, however, only one dome athwartships, these pipes and their valves are to be located at a distance not less than 2.7 [m] from the shell. Where cargo tanks are placed side by side, all the connections to the domes are to be located on the inner side of the domes. The external connections may be located on the fore and aft centre line of the dome. The shut-off devices is to be located directly at the dome or as close as possible to it. The shut-off devices of the loading and unloading piping are to be duplicated, one of the devices being constituted by a remote-controlled quick-action stop device. When the inside diameter of a shut-off device is less than 50 [mm] this device may be regarded as a safety device against bursts in the piping.

6.4.7.2.4 The shore connections are to be located not less than 6 [m] from the entrances to or openings of, the accommodation and service spaces outside the cargo area.

6.4.7.2.5 Each shore connection of the venting piping and shore connections of the piping for loading and unloading, through which the loading or unloading operation is carried out, is to be fitted with a shut-off device and a quick-action stop valve. However, each shore connection is to be fitted with a blind flange when it is not in operation.

6.4.7.2.6 Piping for loading and unloading, and venting piping, is not to have flexible connections fitted with sliding seals.

6.4.7.2.7 Piping for transport of refrigerated liquefied gases

6.4.7.2.7.1 The piping for loading and unloading and cargo tanks is to be protected from excessive stresses due to thermal movement and from movements of the tank and hull structure.

6.4.7.2.7.2 Where necessary, piping for loading and unloading is to be thermally insulated from the adjacent hull structure to prevent the temperature of the hull falling below the design temperature of the hull material.

6.4.7.2.7.3 All piping for loading and unloading, which may be closed off at each end when containing liquid (residue), is to be provided with safety valves. These safety valves are to discharge into the cargo tanks and are to be protected against inadvertent closing.

6.4.7.3 The distance referred to in 6.4.7.1 and 6.4.7.2.4 may be reduced to 3.00 [m] if a transverse bulkhead complying with 6.4.2.1.2 is situated at the end of the cargo area. The openings are to be provided with doors.

The following notice is to be displayed on the doors

**DO NOT OPEN DURING LOADING AND UNLOADING WITHOUT PERMISSION.**

**CLOSE IMMEDIATELY.**

6.4.7.4 Every component of the piping for loading and unloading is to be electrically connected to the hull.

6.4.7.5 The stop valves or other shut-off devices of the piping for loading and unloading are to indicate whether they are open or shut.

6.4.7.6 The piping for loading and unloading are to have, at the test pressure, the required elasticity, leak proofness and resistance to pressure.

6.4.7.7 The piping for unloading is to be fitted with pressure gauges at the inlet and outlet of the pump. Reading of the pressure gauges is to be possible from the control position of the vessel's own gas discharging system. The maximum permissible overpressure or vacuum is to be indicated by a measuring device. Readings are to be possible in all weather conditions.

6.4.7.8 Use of the cargo piping for ballasting purposes is not to be possible.

6.4.7.9 Compressed air generated outside the cargo area or wheelhouse can be used in the cargo area subject to the installation of a spring-loaded non-return valve to ensure that no gases can escape from the cargo area through the compressed air system into accommodation or service spaces outside the cargo area.

6.4.8 Requirements for Electrical Installations

6.4.8.1 Documents concerning electrical installations

6.4.8.1.1 In addition to the other required documentation, the following documents are to be on board:

a) a drawing indicating the boundaries of the cargo area and the location of the electrical equipment installed in this area;

b) a list of the electrical equipment referred to in (a) above including machine or appliance, location, type of protection, type of protection against explosion, testing body and approval number

c) a list of or general plan indicating the electrical equipment outside the cargo area which may be operated during loading, unloading or gas-freeing. All other electrical equipment is to be marked in red. See 6.4.8.3.7 and 6.4.8.3.8.

6.4.8.2 Electrical Installations

6.4.8.2.1 Only distribution systems without return connection to the hull are allowed.

This provision does not apply to:

- active cathodic corrosion protection;
- local installations outside the cargo area (e.g. connections of starters of diesel engines);
- the device for checking the insulation level referred to in 6.4.8.2.2 below:

6.4.8.2.2 Every insulated distribution network is to be fitted with an automatic device with a visual and audible alarm for checking the insulation level.

6.4.8.2.3 For the selection of electrical equipment to be used in zones presenting an explosion risk, the explosion groups and temperature classes assigned to the substances carried in the list of substances are to be taken into consideration (See columns (15) and (16) of Table C of Chapter 3.2 of ADN).

6.4.8.3 Type and Location of Electrical Equipment

6.4.8.3.1 Only the following equipment may be installed in cargo tanks and piping for loading and unloading (comparable to zone 0):

- measuring, regulation and alarm devices of the EEx (ia) type of protection.

6.4.8.3.2 Only the following equipment may be installed in the cofferdams, double-hull spaces, double bottoms and hold spaces (comparable to zone 1)

- measuring, regulation and alarm devices of the certified safe type;
- lighting appliances of the “flame-proof enclosure” or “apparatus protected by pressurization” type of protection;
- hermetically sealed echo sounding devices the cables of which are led through thick-walled steel tubes with gastight connections up to the main deck;
- cables for the active cathodic protection of the shell plating in protective steel tubes such as those provided for echo sounding devices;

The following equipment may be installed only in double-hull spaces and double bottoms if used for ballasting:

- permanently fixed submerged pumps with temperature monitoring, of the certified type.

6.4.8.3.3 Only the following equipment may be installed in the service spaces in the cargo area below deck (comparable to zone 1):

- measuring, regulation and alarm devices of the certified safe type;
- lighting appliances of the “flame-proof enclosure” or “apparatus

protected by pressurization" type of protection;

- motors driving essential equipment such as ballast pumps with temperature monitoring; they are to be of the certified safe type.

6.4.8.3.4 The control and protective equipment of the electrical equipment referred to in 6.4.8.3.1, 6.4.8.3.2 and 6.4.8.3.3 above are to be located outside the cargo area if they are not intrinsically safe.

6.4.8.3.5 The electrical equipment in the cargo area on deck (comparable to zone 1) is to be of the certified safe type.

6.4.8.3.6 Accumulators are to be located outside the cargo area.

6.4.8.3.7 Electrical equipment used during loading, unloading and gas-freeing during berthing and which are located outside the cargo area (comparable to zone 2) are to be at least of the "limited explosion risk" type.

6.4.8.3.7.1 The requirements of 6.4.8.3.7 are not applicable to:

a) lighting installations in the accommodation, except for switches near entrances to accommodation;

b) radiotelephone installations in the accommodation or the wheelhouse;

c) mobile and fixed telephone installations in the accommodation or the wheelhouse;

d) electrical installations in the accommodation, the wheelhouse or the service spaces outside cargo areas if:

   A. These spaces are fitted with a ventilation system ensuring an overpressure of 0.1 [kPa] (0.001 bar) and none of the windows is capable of being opened; the air intakes of the ventilation system located as far away as possible, however, not less than 6 [m] from the cargo area and not less than 2 [m] above the deck;

   B. The spaces are fitted with a gas detection system with sensors:

      i. at the suction inlets of the ventilation system;

      ii. directly at the top edge of the sill of the entrance doors of the accommodation and service spaces when the cargo in the gas phase is heavier than air; otherwise sensors are to be fitted close to the ceiling;

   C. The gas concentration measurement is continuous;

   D. When the gas concentration reaches 20% of the lower explosive limit, the ventilators are to be switched off. In such a case and when the overpressure is not maintained or in the event of failure of the gas detection system, the electrical installations which do not comply with 6.4.8.3.7 above, are to be switched off. These operations are to be performed immediately and automatically and activate the emergency lighting in the accommodation, the wheelhouse and the service spaces, which are to comply at least with the "limited explosion risk" type. The switching-off is to be indicated in the accommodation and wheelhouse by visual and audible signals;

   E. The ventilation system, the gas detection system and the alarm of the switch-off device are to fully comply with the requirements of 6.4.8.3.7 above;

   F. The automatic switch-off device is to be set so that no automatic switching-off may occur while the vessel is under way.

e) Inland AIS (automatic identification systems) stations in the accommodation and in the wheelhouse if no part of an aerial for electronic apparatus is situated above the cargo area and if no part of a VHF antenna for AIS stations is situated within 2 [m] from the cargo area.

6.4.8.3.8 The electrical equipment which does not meet the requirements set out in 6.4.8.3.7 above together with its switches are to be marked in red. The disconnection of such equipment is

to be operated from a centralized location on board.

6.4.8.3.9 An electric generator which is permanently driven by an engine and which does not meet the requirements of 6.4.8.3.7 above, is to be fitted with a switch capable of shutting down the excitation of the generator. A notice board with the operating instructions is to be displayed near the switch.

6.4.8.3.10 Sockets for the connection of signal lights and gangway lighting are to be permanently fitted to the vessel close to the signal mast or the gangway. Connecting and disconnecting is also not to be possible except when the sockets are not live.

6.4.8.3.11 The failure of the power supply for the safety and control equipment is to be immediately indicated by visual and audible signals at the locations where the alarms are usually actuated.

6.4.8.4 Earthing

6.4.8.4.1 The metal parts of electrical appliances in the cargo area which are not live as well as protective metal tubes or metal sheaths of cables in normal service are to be earthed, unless they are so arranged that they are automatically earthed by bonding to the metal structure of the vessel.

6.4.8.4.2 The provisions of 6.4.8.4.1 above apply also to equipment having service voltages of less than 50 [V].

6.4.8.4.3 Independent cargo tanks are to be earthed.

6.4.8.4.4 Receptacles for residual products are to be capable of being earthed.

6.4.8.5 Electrical Cables

6.4.8.5.1 All cables in the cargo area are to have a metallic sheath.

6.4.8.5.2 Cables and sockets in the cargo area are to be protected against mechanical damage.

6.4.8.5.3 Movable cables are prohibited in the cargo area, except for intrinsically safe electric circuits or for the supply of signal lights and gangway lighting.

6.4.8.5.4 Cables of intrinsically safe circuits are only to be used for such circuits and are to be separated from other cables not intended for being used in such circuits (e.g. they are not to be installed together in the same string of cables and they are not to be fixed by the same cable clamps).

6.4.8.5.5 For movable cables intended for signal lights and gangway lighting, only sheathed cables of type H 07 RN-F in accordance with standard IEC 60 245–4:1994 or cables of at least equivalent design having conductors with a cross-section of not less than 1.5 [$mm^2$] are to be used. These cables are to be as short as possible and installed so that damage is not likely to occur.

6.4.8.5.6 The cables required for the electrical equipment referred to in 6.4.8.3.2 and 6.4.8.3.3 are accepted in cofferdams, double-hull spaces, double bottoms, hold spaces and service spaces below deck.

6.4.9 Inspection and Testing

6.4.9.1 Pressure Test

6.4.9.1.1 Cargo tanks and piping for loading and unloading are to comply with the provisions concerning pressure vessels.

6.4.9.1.2 All cofferdams are to be subjected to initial tests before being put into service and thereafter at the prescribed intervals. The test pressure is not to be less than 10 [kPa] (0.10 bar) gauge pressure.

6.4.9.1.3 The maximum intervals for the periodic tests referred to in 6.4.9.1.1 above is to be 11 years.

## Fire Safety Requirements for Tankers Carrying Dangerous Goods

### 7.1 Application

7.1.1 All tankers carrying dangerous goods are to meet the requirements of this section.

### 7.2 Fire-extinguishing arrangements

7.2.1 A fire-extinguishing system is to be installed on the vessel. This system is to comply with the following requirements:

7.2.1.1 It is to be supplied by two independent fire or ballast pumps, one of which is to be ready for use at any time. These pumps and their means of propulsion and electrical equipment are not to be installed in the same space;

7.2.1.2 It is to be provided with a water main fitted with at least three hydrants in the cargo area or wheelhouse above deck. Three suitable and sufficiently long hoses with jet/spray nozzles having a diameter of not less than 12 [mm] are to be provided. Alternatively one or more of the hose assemblies may be substituted by directable jet/spray nozzles having a diameter of not less than 12 [mm]. It is to be possible to reach any point of the deck in the cargo area simultaneously with at least two jets of water which do not emanate from the same hydrant. A spring-loaded non-return valve is to be fitted to ensure that no gases can escape through the fire-extinguishing system into the accommodation or service spaces outside the cargo area;

7.2.1.3 The capacity of the system is to be at least sufficient for a jet of water to have a minimum reach of not less than the vessel's breadth from any location on board with two spray nozzles being used at the same time;

7.2.1.4 The water supply system is to be capable of being put into operation from the wheelhouse and from the deck;

7.2.1.5 Measures are to be taken to prevent the freezing of fire-mains and hydrants.

7.2.2 In addition, the engine rooms, the pump-room and all spaces containing essential equipment (switchboards, compressors, etc.) for the refrigeration equipment, if any, are to be provided with a permanently fixed fire-extinguishing system meeting the following requirements:

7.2.2.1 Extinguishing agents

7.2.2.1.1 For the protection of spaces in engine rooms, boiler rooms and pump rooms, only permanently fixed fire-extinguishing systems using the following extinguishing agents are permitted:

a) $CO_2$ (carbon dioxide);

b) HFC 227 ea (heptafluoropropane);

c) IG-541 (52% nitrogen, 40% argon, 8% carbon dioxide).

d) FK-5-1-12 (dodecafluoro 2-methylpentane-3-one).

7.2.2.2 Ventilation, air extraction

7.2.2.2.1 The combustion air required by the combustion engines which ensure propulsion should not come from spaces protected by permanently fixed fire-extinguishing systems. This requirement is not mandatory if the vessel has two independent main engine rooms with a gastight separation or if, in addition to the main engine room, there is a separate engine room installed with a bow thruster that can independently ensure propulsion in the event of a fire in the main engine room.

7.2.2.2.2 All forced ventilation systems in the space to be protected are to be shut down automatically as soon as the fire-extinguishing system is activated.

7.2.2.2.3 All openings in the space to be protected which permit air to enter or gas to escape are to be fitted with devices enabling them to be closed rapidly. It is to be clear whether they are open or closed.

7.2.2.2.4 Air escaping from the pressure–relief valves of the pressurised air tanks installed in the engine rooms is to be evacuated to the open air.

7.2.2.2.5 Overpressure or negative pressure caused by the diffusion of the extinguishing agent is not to destroy the constituent elements of the space to be protected. It is to be possible to ensure the safe equalisation of pressure.

7.2.2.2.6 Protected spaces are to be provided with a means of extracting the extinguishing agent. If extraction devices are installed, it is not to be possible to start them up during extinguishing.

7.2.2.3 Fire alarm system

7.2.2.3.1 The space to be protected is to be monitored by an appropriate fire alarm system. The alarm signal is to be audible in the wheelhouse, the accommodation and the space to be protected.

7.2.2.4 Piping system

7.2.2.4.1 The extinguishing agent is to be routed to and distributed in the space to be protected by means of a permanent piping system. Piping

installed in the space to be protected and their fittings are to be made of steel. This does not apply to the connecting nozzles of tanks and compensators provided that the materials used have equivalent fire retardant properties. Piping is to be protected against corrosion both internally and externally.

7.2.2.4.2 The discharge nozzles are to be so arranged as to ensure the regular diffusion of the extinguishing agent. In particular, the extinguishing agent must also be effective beneath the floor.

7.2.2.5 Triggering device

7.2.2.5.1 Automatically activated fire-extinguishing systems are not permitted.

7.2.2.5.2 It is to be possible to activate the fire-extinguishing system from a suitable point located outside the space to be protected.

7.2.2.5.3 Triggering devices are to be so installed that they can be activated in the event of a fire and so that the risk of their breakdown in the event of a fire or an explosion in the space to be protected is reduced as far as possible. Systems which are not mechanically activated are to be supplied from two energy sources independent of each other. These energy sources are to be located outside the space to be protected. The control lines located in the space to be protected are to be so designed as to remain capable of operating in the event of a fire for a minimum of 30 minutes. The electrical installations are deemed to meet this requirement if they conform to the IEC 60331–21:1999 standard. When the triggering devices are so placed as not to be visible, the component concealing them are to carry the "Fire-fighting system" symbol, each side being not less than 10 [cm] in length, with the following text in red letters on a white ground:

**FIRE-EXTINGUISHING SYSTEM**

7.2.2.5.4 If the fire-extinguishing system is intended to protect several spaces, it is to comprise a separate and clearly–marked triggering device for each space.

7.2.2.5.5 The instructions are to be posted alongside all triggering devices and are to be clearly visible and indelible. The instructions are to be in a language the master can read and understand. They are to include information concerning:

a) the activation of the fire-extinguishing system;

b) the need to ensure that all persons have left the space to be protected;

c) The correct behaviour of the crew in the event of activation and when accessing the space to be protected following activation or diffusion, in particular in respect of the possible presence of dangerous substances;

d) the correct behaviour of the crew in the event of the failure of the fire extinguishing system to function properly.

7.2.2.5.6 The instructions are to mention that prior to the activation of the fire-extinguishing system, combustion engines installed in the space and aspirating air from the space to be protected, are to be shut down.

7.2.2.6 Alarm device

7.2.2.6.1 Permanently fixed fire-extinguishing systems are to be fitted with an audible and visual alarm device.

7.2.2.6.2 The alarm device is to be set off automatically as soon as the fire-extinguishing system is first activated. The alarm device is to function for an appropriate period of time before the extinguishing agent is released; it is not to be possible to turn it off.

7.2.2.6.3 Alarm signals are to be clearly visible in the spaces to be protected and their access points and be clearly audible under operating conditions corresponding to the highest possible sound level. It is to be possible to distinguish them clearly from all other sound and visual signals in the space to be protected.

7.2.2.6.4 Sound alarms are to also be clearly audible in adjoining spaces, with the communicating doors shut, and under operating

conditions corresponding to the highest possible sound level.

7.2.2.6.5 If the alarm device is not intrinsically protected against short circuits, broken wires and drops in voltage, it is to be possible to monitor its operation.

7.2.2.6.6 A sign with the following text in red letters on a white background is to be clearly posted at the entrance to any space the extinguishing agent may reach:

**WARNING, FIRE-EXTINGUISHING SYSTEM!**

**LEAVE THIS SPACE IMMEDIATELY WHEN THE … (DESCRIPTION) ALARM IS ACTIVATED!**

7.2.2.7 Pressurised tanks, fittings and piping

7.2.2.7.1 Pressurised tanks, fittings and piping are to conform to the requirements of the competent authority.

7.2.2.7.2 Pressurised tanks are to be installed in accordance with the manufacturer's instructions.

7.2.2.7.3 Pressurised tanks, fittings and piping are not to be installed in the accommodation.

7.2.2.7.4 The temperature of cabinets and storage spaces for pressurised tanks is not to exceed 50 [°C].

7.2.2.7.5 Cabinets or storage spaces on deck are to be securely stowed and are to have vents so placed that in the event of a pressurised tank not being gastight, the escaping gas cannot penetrate into the vessel. Direct connections with other spaces are not permitted.

7.2.2.8 Quantity of extinguishing agent

7.2.2.8.1 If the quantity of extinguishing agent is intended for more than one space, the quantity of extinguishing agent available does not need to be greater than the quantity required for the largest of the spaces thus protected.

7.2.2.9 Installation, maintenance, monitoring and documents

7.2.2.9.1 The mounting or modification of the system is to only be performed by a company specialised in fire-extinguishing systems. The instructions (product data sheet, safety data sheet) provided by the manufacturer of the extinguishing agent or the system are to be followed.

7.2.2.9.2 The system is to be inspected by an expert:

a) before being brought into service;

b) each time it is put back into service after activation;

c) after every modification or repair;

d) regularly, not less than every two years.

7.2.2.9.3 During the inspection, the expert is required to check that the system conforms to the requirements of 7.2.2.

7.2.2.9.4 The inspection is to include, as a minimum:

a) an external inspection of the entire system;

b) an inspection to ensure that the piping is leakproof;

c) an inspection to ensure that the control and activation systems are in good working order;

d) an inspection of the pressure and contents of tanks;

e) an inspection to ensure that the means of closing the space to be protected are leakproof;

f) an inspection of the fire alarm system;

g) an inspection of the alarm device.

7.2.2.10 Fire-extinguishing system operating with $CO_2$

7.2.2.10.1 In addition to the requirements contained in 7.2.2.1 to 7.2.2.9, fire-extinguishing systems using $CO_2$ as an extinguishing agent are to conform to the following provisions:

7.2.2.10.1.1 Tanks of $CO_2$ are to be placed in a gastight space or cabinet separated from other spaces. The doors of such storage spaces and cabinets are to open outwards; they are to be capable of being locked and

are to carry on the outside the symbol "Warning: danger", not less than 5 [cm] high and "$CO_2$" in the same colours and the same size;

7.2.2.10.1.2 Storage cabinets or spaces for $CO_2$ tanks located below deck are only to be accessible from the outside. These spaces are to have an artificial ventilation system with extractor hoods and are to be completely independent of the other ventilation systems on board;

7.2.2.10.1.3 The level of filling of $CO_2$ tanks is not to exceed 0.75 [kg/l]. The volume of depressurised $CO_2$ is to be taken to be 0.56 [$m^3$/kg];

7.2.2.10.1.4 The concentration of $CO_2$ in the space to be protected is to be not less than 40% of the gross volume of the space. This quantity is to be released within 120 seconds. It is to be possible to monitor whether diffusion is proceeding correctly;

7.2.2.10.1.5 The opening of the tank valves and the control of the diffusing valve are to correspond to two different operations;

7.2.2.10.1.6 The appropriate period of time mentioned in 7.2.2.6 b) is to be not less than 20 seconds. A reliable installation is to ensure the timing of the diffusion of $CO_2$.

7.2.2.11 Fire-extinguishing system operating with HFC-227 ea (heptafluoropropane)

7.2.2.11.1 In addition to the requirements of 7.2.2.1 to 7.2.2.9, fire-extinguishing systems using HFC-227 ea as an extinguishing agent is to conform to the following provisions:

7.2.2.11.1.1 Where there are several spaces with different gross volumes, each space is to be equipped with its own fire-extinguishing system;

7.2.2.11.1.2 Every tank containing HFC-227 ea placed in the space to be protected is to be fitted with a device to prevent overpressure. This device is to ensure that the contents of the tank are safely diffused in the space to be protected if the tank is subjected to fire, when the fire-extinguishing system has not been brought into service;

7.2.2.11.1.3 Every tank is to be fitted with a device permitting control of the gas pressure;

7.2.2.11.1.4 The level of filling of tanks is not to exceed 1.15 [kg/l]. The specific volume of depressurised HFC-227 ea is to be taken to be 0.1374 [$m^3$/kg];

7.2.2.11.1.5 The concentration of HFC-227 ea in the space to be protected is to be not less than 8% of the gross volume of the space. This quantity is to be released within 10 seconds;

7.2.2.11.1.6 Tanks of HFC-227 ea are to be fitted with a pressure monitoring device which triggers an audible and visual alarm in the wheelhouse in the event of an unscheduled loss of propellant gas. Where there is no wheelhouse, the alarm is to be triggered outside the space to be protected;

7.2.2.11.1.7 After discharge, the concentration in the space to be protected is not to exceed 10.5% (volume);

7.2.2.11.1.8 The fire-extinguishing system is not to comprise aluminium parts.

7.2.2.12 Fire-extinguishing system operating with IG-541

7.2.2.12.1 In addition to the requirements of 7.2.2.1 to 7.2.2.9, fire-extinguishing systems using IG-541 as an extinguishing agent is to conform to the following provisions:

7.2.2.12.1.1 Where there are several spaces with different gross volumes, every space is to be equipped with its own fire-extinguishing system;

7.2.2.12.1.2 Every tank containing IG-541 placed in the space to be protected is to be fitted with a device to prevent overpressure. This device is to ensure that the contents of the tank are safely diffused in the space to be protected if the tank is subjected to fire, when the fire-extinguishing system has not been brought into service;

7.2.2.12.1.3 Each tank is to be fitted with a device for checking the contents;

7.2.2.12.1.4 The filling pressure of the tanks is not to exceed 200 [bar] at a temperature of +15 [°C];

7.2.2.12.1.5 The concentration of IG-541 in the space to be protected is to be not less than 44% and not more than 50% of the gross volume of the space. This quantity is to be released within 120 seconds.

7.2.2.13 Fire-extinguishing system operating with FK-5-1-12

7.2.2.13.1 In addition to the requirements of 7.2.2.1 to 7.2.2.9, fire-extinguishing systems using FK-5-1-12 as an extinguishing agent is to comply with the following provisions:

7.2.2.13.1.1 Where there are several spaces with different gross volumes, every space is to be equipped with its own fire-extinguishing system;

7.2.2.13.1.2 Every tank containing FK-5-1-12 placed in the space to be protected is to be fitted with a device to prevent overpressure. This device is to ensure that the contents of the tank are safely diffused in the space to be protected if the tank is subjected to fire, when the fire-extinguishing system has not been brought into service;

7.2.2.13.1.3 Every tank is to be fitted with a device permitting control of the gas pressure;

7.2.2.13.1.4 The level of filling of tanks is not to exceed 1[kg/l]. The specific volume of depressurized FK-5-1-12 is to be taken to be 0.0719 [$m^3$/kg];

7.2.2.13.1.5 The volume of FK-5-1-12 in the space to be protected is to be not less than 5.5% of the gross volume of the space. This quantity is to be released within 10 seconds;

7.2.2.13.1.6 Tanks of FK-5-1-12 are to be fitted with a pressure monitoring device which triggers an audible and visual alarm in the wheelhouse in the event of an unscheduled loss of extinguishing agent. Where there is no wheelhouse, the alarm is to be triggered outside the space to be protected;

7.2.2.13.1.7 After discharge, the concentration in the space to be protected is not to exceed 10.0%.

7.2.3 Vessel is to be equipped with at least two additional hand fire-extinguishers, which are to be located in the cargo area. The fire extinguishing agent contained in these additional hand fire-extinguishers is to be suitable for fighting fires involving the dangerous good carried.

7.2.4 The fire-extinguishing agent and the quantity contained in the permanently fixed fire-extinguishing system is to be suitable and sufficient for fighting fires.

**7.3 Fire and naked light**

7.3.1 The outlets of funnels are to be located not less than 2 [m] from the cargo area. Arrangements are to be provided to prevent the escape of sparks and the entry of water.

7.3.2 Heating, cooking and refrigerating appliances are not to be fuelled with liquid fuels, liquid gas or solid fuels. The installation in the engine room or in another separate space of heating appliances fueled with liquid fuel having a flash–point above 55 [°C] is, however, permitted. Cooking and refrigerating appliances are permitted only in the accommodation.

7.3.3 Only electrical lighting appliances are permitted.

## Chapter 3

## Passenger Vessels

Contents



### Section 1

### General

**1.1 Application**

1.1.1 This Chapter applies to self-propelled passenger vessels.

1.1.2 Attention is drawn to technical and operational requirements of National/Local authorities where the vessel is registered or operating.

**1.2 Definitions**

1.2.1 **Passenger vessel**: a day trip or cabin vessel constructed and equipped to carry more than 12 passengers.

1.2.2 **Day-trip vessel**: a passenger vessel without overnight passenger cabins.

1.2.3 **Cabin vessel**: a passenger vessel with overnight passenger cabins.

1.2.4 **Main Engine Room**: Space where the propulsion engines are installed

1.2.5 **Engine Room**: Space where combustion engines are installed.

1.2.6 **Boiler Room**: a space housing a fuel-operated installation designed to produce steam or heat a thermal fluid.

1.2.7 **Wheelhouse**: the area which houses all the control and monitoring instruments necessary for manoeuvring the vessel.

1.2.8 **Crew Accommodation**: a space intended for the use of persons normally living on board, including galleys, store rooms, toilets and washing facilities, laundry facilities, passageways, but not the wheelhouse.

1.2.9 **Passenger Space**: space on board intended for passengers and enclosed areas such as offices, shops, hairdressing salons, drying rooms, laundries, saunas, toilets, washrooms, passageways, connecting passages and stairs not encapsulated by walls.

1.2.10 **Accommodation Space**: a living space of a crew accommodation or a passenger space. On board passenger vessels, galleys are not regarded as accommodation space.

1.2.11 **Stairwell**: the well of an internal staircase or of a lift.

1.2.12 **Galley**: a room equipped with an open flame cooking appliance or any electrically heated cooking plate or hot plate with a power of not more than 5 [kW].

1.2.13 **Muster Areas**: areas of the vessel which are specially protected and in which persons muster in the event of danger.

1.2.14 **Evacuation Areas**: part of muster areas of the vessel from which evacuation of persons can be carried out.

1.2.15 **Store Room of high risk**: a space for the storage of flammable liquids or a room with an area of over 4 [$m^2$] for storing supplies.

1.2.16 **Passageway**: an area intended for the normal movement of persons and goods.

1.2.17 **Persons with reduced mobility**: persons facing particular problems when using public transport, such as the elderly and the handicapped and persons with sensory disabilities, persons in wheelchairs, pregnant women and persons accompanying young children.

**1.3 Material**

1.3.1 Glass doors and walls in passageways and also window panes are to be manufactured from pre-stressed glass or laminated glass. They may also be made from a synthetic material.

**Section 2**

**Vessel Arrangement**

**2.1 Stability and Freeboard**

2.1.1 The intact stability, damage stability and freeboard of the vessel are to be in accordance with relevant sections of Chapter III of the Inland Vessels (Design and Construction) Rules, 2022.

2.1.2 The maximum draught is to be in compliance with the requirements of 2.1.1 and is to be marked on the vessel's sides at about mid-length.

**2.2 Subdivision and Transverse Bulkheads**

2.2.1 The number and position of bulkheads are to be selected such that, in the event of flooding, the vessel remains buoyant according to the requirements used for the compliance of 2.1.1. Every portion of the internal structure, which affects the efficiency of the subdivision of such vessels, is to be watertight, and is to be of a design which will maintain the integrity of the subdivision.

2.2.2 Bulkheads rising up to the deck are to be provided as follows :

क) A Collision Bulkhead: The distance between the collision bulkhead and the forward perpendicular is to be at least 0.04LWL and not more than 0.04LWL + 2 [m].

ख) An Aft-Peak Bulkhead, where vessel length exceeds 25 [m]: The aft peak bulkhead is to be installed at a distance of between 1.4 [m] and 0.04 LWL + 2 [$m$] measured from the aft point of the intersection of the hull with the maximum draught line.

2.2.3 A transverse bulkhead may be fitted with a bulkhead recess, if all parts of this recess lie within the area which is externally bounded by a vertical surface running at a distance of $B_{WL}/5$ parallel to the course of the hull in the line of maximum draught.

2.2.4 The bulkheads, which are taken into account in the damage stability calculations, are to be watertight and are to extend up to the bulkhead deck.

2.2.5 The number of openings in the bulkheads referred above in 2.2.4 are to be kept to the minimum consistent with the type of construction and normal operation of the vessel. Openings and penetrations are not to have a detrimental effect on the watertight function of the bulkheads.

2.2.6 Collision bulkheads are to have no openings and no doors.

2.2.7 Doors are not permitted in bulkheads separating the engine rooms from passenger space or crew accommodation.

2.2.8 Where double bottoms are fitted, their height is to be at least 0.65 [m], and where wing voids are fitted, their width is to be at least 0.65 [m].

**2.3 Watertight Doors and Doors**

2.3.1 Manually operated doors without remote control, in bulkheads referred to in 2.2.4, are permitted only in areas not accessible to passengers. They are to:

a) remain closed at all times and be opened only temporarily to allow access;

b) be fitted with suitable devices to enable them to be closed quickly and safely;

c) display the following notice on both sides of the doors:

**'Close door immediately after passing through'.**

A manually controlled remote controlled bulkhead door in the passenger space may be provided on vessels of length not more than 45[m] and authorized to carry number of passengers restricted to that length of the vessel in meters, if:

a) the vessel has only one deck;

b) this door is accessible directly from the deck and is not more than 10 [m] away from the deck;

c) the lower edge of the door opening lies at least 0.3 [m]above the floor of the passenger space, and

d) each of the compartments divided by the door is fitted with a bilge level alarm.

2.3.2 Doors in bulkheads referred to in 2.2.4 that are open for long periods are to comply with the following requirements:

a) they are to be capable of being closed from both sides of the bulkhead and from an easily accessible point above the bulkhead deck;

b) after being closed by remote control, the door is to be such that it can be opened again locally and closed safely. Closure is not to be impeded by carpeting, foot rails or other obstructions;

c) the time taken for the remote-controlled closure process is to be at least 30 [seconds] but not more than 60 [seconds];

d) during the closure procedure an audible alarm is to sound by the door;

e) the door drive and alarm are also to be capable of operating independently of the on-board power supply. There is to be a device at the location of the remote control that displays whether the door is open or closed.

2.3.3 Doors in bulkheads referred to in 2.2.4, and their actuators are to be located in the area which is externally bounded by a vertical surface running at a

distance of $B_{WL}/5$ parallel to the course of the hull in the line of maximum draught.

2.3.4 There is to be a warning system in the wheelhouse to indicate which of the doors in bulkheads referred to in 2.2.4 are open.

2.3.5 Remote controls of bulkhead doors according to 2.3.2 are to be clearly indicated as such.

2.3.6 Cold-storage room doors, even when locked, are also to be capable of being opened from the inside.

**2.4 Windows**

2.4.1 Windows may be situated below the margin line if they are watertight, cannot be opened, possess sufficient strength, protected by deadlights or portable covers and conform to 1.6.1.

2.4.2 Requirements of 2.4.1 are deemed to be fulfilled if the construction of watertight windows complies with the following provision:

a) Pre-stressed glass complying with International Standard ISO 614 : 2012 is used.

b) Round windows comply with International Standard

- ISO 1751 : 2012,
- Series B: medium heavy-duty windows
- Type: non-opening window.

c) Angular windows comply with International Standard

- ISO 3903 : 2012,
- Series E: heavy-duty windows
- Type: non-opening window

d) ISO Standard windows may be replaced by windows whose construction is at least equivalent to the requirements of b) to c).

2.4.3 Cabins without an opening window are to be connected to a ventilation system.

**2.5 Passenger Spaces**

**2.5.1 Location of Passenger Spaces**

2.5.1.1 On all decks, passenger spaces are to be located aft of the collision bulkhead and, if they are below the bulkhead deck, forward of the aft-peak bulkhead.

2.5.1.2 Passenger spaces are to be separated from the engine and boiler rooms by gas-tight boundaries.

2.5.1.3 Deck areas, which are enclosed by awnings or similar mobile installations not only above but also fully or partially to the side, are to comply with the same requirements as enclosed passenger spaces.

**2.5.2 Number and Width of the Exits of Passenger Spaces**

2.5.2.1 The number and width of the exits of passenger spaces are to comply with the following requirements:

a) Rooms or groups of rooms designed or arranged for 30 or more passengers or including berths for 12 or more passengers, are to have at least two exits. On day trip vessels, one of these two exits can be replaced by two emergency exits. Rooms, with the exception of cabins, and groups of rooms that have only one exit, are to have at least one emergency exit.

b) If rooms are located below the bulkhead deck, one of the exits can be a watertight bulkhead door, (complying with 2.3.2), leading into an adjacent compartment from which the upper deck can be reached directly. The other exit is to lead directly or, if permitted in accordance with (a), as an emergency exit into the open air, or to the bulkhead deck. This requirement does not apply to individual cabins.

c) Exits according to (a) and (b) are to be suitably arranged and are to have a clear width of at least 0.8 [m] and a clear height of at least 2 [m]. For doors of passenger cabins and other small rooms, the clear width can be reduced to 0.7 [m].

d) In the case of rooms or groups of rooms intended for more than 80 passengers the sum of the widths of all exits intended for passengers and which are to be used by them in an emergency is to be at least 0.01 [m] per passenger.

e) If the total width of the exits is determined by the number of passengers, the width of each exit is to be at least 0.005 [m] per passenger.

f) Emergency exits are to have a shortest side at least 0.6 [m] long or a minimum diameter of 0.7 [m]. They are to open in the direction of escape and be marked on both sides.

**2.5.3 Doors of Passenger Spaces**

2.5.3.1 Doors of passenger spaces are to comply with the following requirements:

a) With the exception of doors leading to connecting corridors, they are to be capable of opening outwards or be constructed as sliding doors.

b) Cabin doors are to be made in such a way that they can also be unlocked from the outside at any time.

c) Powered doors are to open easily in the event of failure of the power supply to this mechanism.

**2.5.4 Corridors**

2.5.4.1 Connecting corridors are to comply with the following requirements:

a) They are to have a clear width of at least 0.8 [m]. If they lead to rooms used by more than 80 passengers, they are to comply with the provisions mentioned in 2.5.2.1(d) and (e) regarding the width of the exits leading to connecting corridors.

b) Their clear height is not to be less than 2 [m].

c) Connecting corridors more than 1.5 [m] wide are to have handrails on either side.

d) Where a part of the vessel or a room intended for passengers is served by a single connecting corridor, the clear width thereof is to be at least 1 [m].

e) Connecting corridors are to be free of steps.

f) They are to lead only to open decks, rooms or staircases.

g) Dead ends in connecting corridors are not to be longer than two meters.

**2.5.5 Stairs and their Landing**

2.5.5.1 Stairs and their landings in the passenger spaces are to comply with the following requirements:

a) They are to be constructed in accordance with a recognized national/international standard.

b) They are to have a clear width of at least 0.8 [m]. If they lead to connecting corridors or areas used by more than 80 passengers, the stairs are to have a width of at least 0.01 [m] per passenger.

c) They are to have a clear width of at least 1 [m] if they provide the only means of access to a room intended for passengers.

d) Staircases in the same room are to be provided on each side of the vessel. In case, staircases in the same room are not provided on each side, then the staircases have to be in area, which is externally bounded by a vertical surface running at a distance of $B_{WL}/5$ parallel to the course of the hull in the line of maximum draught area.

**2.5.6 Bulwarks and Guard Rail**

2.5.6.1 Parts of the deck intended for passengers, and which are not enclosed, are to comply with the following requirements:

a) They are to be surrounded by a fixed bulwark or guard rail at least 1 [m] high or a railing according a recognized standard such as IS 19448.

**2.5.7 Embarking and Disembarking Arrangement**

2.5.7.1 Parts of the deck intended for passengers, and which are not enclosed, are to comply with the following requirements:

a) Openings and equipment for embarking or disembarking and openings for loading or unloading are to be such that they can be secured and have a clear width of at least 1 [m].

b) If the openings and equipment for embarking or disembarking cannot be observed from the wheelhouse, appropriate auxiliary means are to be provided.

**2.6 Escape from Passenger Spaces**

2.6.1 In addition to the provisions of 2.5.4.1, escape routes are to also comply with the following requirements:

a) Stairways, exits and emergency exits are to be so arranged that, in the event of a fire in any given area, the other areas may be evacuated safely.

b) The escape routes are to lead by the shortest route to evacuation areas.

c) Escape routes are not to lead through engine rooms or galleys.

d) There are to be no rungs, ladders or the like installed at any point along the escape routes.

e) Doors to escape routes are to be constructed in such a way as not to reduce the minimum width of the escape route referred to in 2.5.4.1(a) or (d).

f) Escape routes and emergency exits are to be clearly indicated by signs. The signs are to be lit by the emergency lighting system.

2.6.2 Escape routes and emergency exits are to have a suitable safety guidance system (*Refer Section 4, 4.7*).

**2.7 Warning against Unauthorized Entry**

2.7.1 The parts of the vessels not intended for passengers, in particular access to the wheelhouse, to the winches and to the engine rooms, are to be such that they can be secured against unauthorised entry. At any such access, a warning symbol/sign is to be displayed in a prominent position.

**2.8 Passageways in Passenger spaces**

2.8.2 Transparent doors and transparent walls (if fitted) extending as far as the floor in passageways are to be prominently marked.

**2.9 Superstructure**

2.9.1 Superstructures (or their roofs) consisting entirely of panoramic panes, shelters created by awnings, or similar mobile installations, together with their substructures, may only be constructed in such a manner that the way in which they are built and the materials employed pose no risk of injury to persons on board in the event of damage.

2.9.2 Rooms in which crew members are accommodated are to comply with the provisions of this section, as far as practicable.

**2.10 Tanks and Cofferdams**

2.10.1 Tanks containing fuel oil/lubricating oil are to be separated from passenger, crew and baggage compartments by a gastight and watertight boundary or alternatively by a cofferdam.

2.10.2 A cofferdam between the passenger, crew and baggage compartments is mandatory when the common bulkhead is subject to a static liquid pressure under normal service conditions.

## Section 3

## Machinery and Systems

**3.1 Bilge System**

**3.1.1 General**

3.1.1.1 Requirements of this sub-section are to be complied with, in addition to the requirements of Annex 3, Ch.3, Sec.2.

3.1.1.2 A bilge pumping system with permanently installed pipe work is to be provided.

3.1.1.3 The bilge pumping plant is to be capable of draining any watertight compartment under all practicable conditions after a casualty, whether the vessel is upright or listed.

**3.1.2 Number of Pumps**

3.1.2.1 Two independent power driven bilge pumps are to be provided.

**3.1.3 Arrangement of bilge pumps and bilge main**

**3.1.3.1 Bilge Pumps**

3.1.3.1.1 The power bilge pumps are to be placed in separate watertight compartments, which will not readily be flooded by the same damage.

3.1.3.1.2 The arrangements are to be such that at least one power pump will be available for use in all ordinary circumstances in which the vessel may be flooded. This requirement will be satisfied if:

a) one of the pumps is an emergency pump of a submersible type having a source of power situated above the bulkhead deck;

or

b) the pumps and their sources of power are so disposed throughout the length of the vessel that, under any conditions of flooding which the vessel is required to withstand ~~by Statutory Regulations~~ at least one pump in an undamaged compartment will be available.

**3.1.3.2 Bilge Main**

3.1.3.2.1 The bilge main is to be so arranged that no part is situated nearer the side of the vessel than , B/5 measured at right angles to the centreline at the level of the deepest load line, where *B* is the breadth of the vessel.

3.1.3.2.2 Where any bilge pump or its pipe connection to the bilge main is situated outboard of the line B/5, then a non-return valve is to be provided in the pipe connection at the junction with the bilge main. The emergency bilge pump and its connections to the bilge main are to be so arranged that they are situated inboard of the line B/5

**3.1.3.3 Bilge Valves**

3.1.3.3.1 All manifolds and valves fitted in connection with the bilge pumping arrangements are to be located in positions which are readily accessible at all times under normal circumstances. If in any such vessel there is only one system of bilge pipes common to all such pumps, the necessary valves for controlling the bilge suctions are to be capable of being operated from above the vessel's bulkhead deck.

3.1.3.3.2 Where, in addition to the main bilge pumping system, an emergency bilge pumping system is provided, it is to be independent of the main system and so arranged that a pump is capable of operating on any compartment under flooding conditions; in this case, the valves and cocks necessary for the operation of the emergency system need to be capable of being operated from above the bulkhead deck.

3.1.3.3.3 Every valve which is required to be operated from above the bulkhead deck is to have its means of control, at its place of operation, clearly marked to show the purpose it serves and how it may be opened and closed. It is to be provided with a means to indicate whether it is open or closed.

**3.1.4 Requirement for bilge pumps and bilge suction**

3.1.4.1 Every bilge pump provided is to be self-priming.

3.1.4.2 Each independent bilge pump is to have a direct bilge suction from the space in which it is situated, but not more than two such suctions are required in any one space. Where two or more suctions are provided, there is to be at least one suction at each side of the space.

3.1.4.3 All bilge suctions are to be fitted with readily accessible strainers so that they may be regularly checked and cleaned.

3.1.4.4 Provision is to be made to prevent the compartment served by any bilge suction pipe being flooded, in the event of the pipe being severed, or otherwise damaged by collision or grounding in any other compartment. For this purpose, where the pipe is at any part situated nearer the side of the vessel than B/5 or less than 0.5 [m] above the bottom, a non-return valve is to be fitted to the pipe in the compartment containing the open end.

**3.1.5 Bilge Alarms**

3.1.5.1 A bilge alarm is to be fitted;

a) in any compartment containing propulsion machinery; and
b) in any other compartment likely to accumulate bilge water.
c) The alarm is to provide an audible warning, and a separate visual warning, for each protected space at the control position. Once activated the audible alarm is to continue to sound until acknowledged.

**3.2 Air and Sounding Pipes**

3.2.1 Short sounding pipes are permissible only for sounding cofferdams and double bottom tanks situated in a machinery space, and are in all cases to be fitted with self-closing cocks as described in Annex 3, Ch.3, 3.3.4. In addition:

a) Short sounding pipes to fuel oil, (flash point not less than 55°C), lubricating oil tanks and other flammable oil tanks (flash point not less than 55°C) are to be fitted with an additional small diameter self-closing test cock, in order to ensure that the sounding pipe is not under a pressure of oil before opening-up the sounding cock.
b) Provision is to be made to ensure that discharge of oil through this test cock does not present an ignition hazard.
c) An additional small diameter self-closing test cock is not required for lubricating oil tanks.

3.2.2 Elbow sounding pipes are not permitted.

3.2.3 Sounding pipes of fuel tanks are not to terminate in accommodation or passenger spaces.

**3.3 Prevention of communication between compartments in the event of damage**

3.3.1 Open ended pipes and ventilation ducts are to be arranged such that in any condition of flooding, water cannot enter other watertight compartments:

a) If several compartments are connected by means of open ended pipelines or ventilation ducts they are to be arranged such that the open ends are situated above the maximum assumed damage condition.
b) Pipelines/ ventilation ducts are not required to comply with (a) above if they are provided with shut off valves capable of being operated from above the bulkhead deck. Shut-off devices above the bulkhead deck are to be clearly indicated as such.
c) Pipelines having no open end are to be considered as not damaged if they are situated inboard of the line B/5 and the distance from the bottom is more than 0.5 [m]

## Section 4

## Electrical Installations

**4.1 General**

4.1.1 The electrical equipment and installations (including any electrical means of propulsion) are to be such that the vessel and all persons onboard are protected against electrical hazards.

4.1.2 The electrical equipment and installations are to be maintained to ensure that the vessel is in an operational and habitable condition.

4.1.3 The main source of electrical power may be driven by auxiliary or the main propulsion engine. It is to be capable of illuminating any part of the vessel normally accessible to and used by the passengers or crew, and provide power to main electrical systems, which are to operate without recourse to the emergency source of power.

**4.2 Emergency source of electrical power**

**4.2.1 General**

4.2.1.1 All passenger vessels are to be provided with an emergency source of electrical power.

4.2.1.2 A failure of the main or emergency power equipment is not to mutually affect the operational safety of the installations.

**4.2.2 Equipment/Systems requiring Emergency Source of Power**

4.2.2.1 Emergency source of power is to be provided to supply the following:

a) navigation lights;

b) search lights

c) audible warning devices;

d) emergency lighting;

e) radiotelephone installations;

f) general alarm, PA System and on-board message communications systems essential for safety and operation of vessel;

g) passenger and crew warning systems;

h) fire detection and alarm systems;

i) fire-extinguishing systems and fire-extinguishing media release alarms;

j) automatic sprinkler systems;

k) control and power systems to power-operated watertight doors and fire doors and their status indication;

l) personnel lifts and lifting equipment for persons with reduce mobility provided for evacuation purposes;

m) emergency bilge pump and equipment necessary for the operation of remote controlled bilge valves; and

n) davits and hoisting gear for gangways intended for emergency use and rescue boats, where installed.

**4.2.3 Operating Period of Emergency power supply**

4.2.3.1 The emergency source of power is to be capable of powering the items listed in 4.2.2.1 without refueling or recharging for a projected operating period depending on the purpose of the vessel and as agreed by the national/local authority. In any case, the operating period of the emergency of power is not to be less than 60 [minutes].

**4.2.4 Arrangement**

4.2.4.1 The emergency power plant is to be installed outside the main engine room, outside the rooms housing the main power sources and outside the room where the main switchboard is located; it is to be separated from these rooms by partitions according to Section 5. The emergency power plant is to be installed either above the margin line or as far away as possible from the main power sources, to ensure that, in the event of flooding, it is not flooded at the same time as these power sources.

4.2.4.2 Cables feeding the electrical installations in the event of an emergency are to be installed and routed in such a way as to maintain the continuity of supply of these installations in the event of fire or flooding affecting the main power supply. Unless emergency power cables are suitably protected against fire and flame to a duration as decided in 4.2.3.1, they are not to be routed through the main engine room, galleys or space where the main power source and connected equipment is installed, except where necessary to provide power to emergency equipment in such areas.

4.2.4.3 The emergency switchboard is to be installed as near as is practicable to the emergency source of power.

**4.2.5 Types of Emergency Source of Electrical Power**

4.2.5.1 The following are admissible for use as an emergency source of power:

a) auxiliary generator sets with their own independent fuel (flash point of not less than 43[°C]) supply, and independent cooling system which, in the event of a power failure, start and take over the supply of power within 30 [seconds] automatically or, if they are located in the immediate vicinity of the wheelhouse or any other location permanently manned by crew members, can be brought into operation manually; or

b) accumulator batteries, which, in the event of a power failure, connect automatically or, if they are located in the immediate vicinity of the wheelhouse or any other location permanently manned by crew members, can be connected manually. Accumulator battery banks are to be capable of being isolated. They are to be capable of powering the power consumers as mentioned in 4.2.2.1 throughout the prescribed period without recharging and without an unacceptable voltage reduction.

To enable the crew to undertake a) or b) above, emergency battery lighting is to be provided in way of the emergency means of power supply described. This may be by the use of torches stowed in a readily accessible place nearby.

**4.2.6 Control and Monitoring**

4.2.6.1 Where emergency generating sets are fitted they are to be capable of being started readily when cold.

4.2.6.2 The emergency switchboard may be supplied from the main switchboard during normal operation.

4.2.6.3 Where the emergency source of power is an accumulator battery, arrangements are to be such that

emergency lighting will automatically come into operation on failure of the main lighting supply.

4.2.6.4 An indicator is to be mounted in the machinery space, or in the wheelhouse, to indicate when any accumulator battery fitted in accordance with 4.2.5 is being discharged.

**4.3 Lighting**

**4.3.1 General**

4.3.1.1 Only electrical equipment are permitted for lighting.

4.3.1.2 When two or more lighting appliances are installed in an engine room or boiler room, they are to be distributed between at least two circuits. This requirement also apply to rooms where cooling machinery, hydraulic machinery or electric motors are installed.

4.3.1.3 In the important spaces mentioned below the lighting is to be supplied by at least two different circuits:

a) Passageways

b) stairways leading to the boat deck, and public spaces and day rooms for passengers and crew

c) large galleys.

The lamps are to be so arranged that adequate lighting is maintained even if one of the circuits fails.

4.3.1.4 If a vessel is divided into fire zones, at least two circuits are to be provided for the lighting of each fire zone, and each of these must have its own power supply line. One circuit is to be supplied from the emergency power source. The supply lines are to be so located that, in the event of a fire in one main fire zone, the lighting in the other zones is as far as practicable maintained.

**4.3.2 Main Lighting**

4.3.2.1 There is to be a main lighting system supplied by the main source of electrical power and illuminating all parts of the vessel normally accessible to the passengers and crew.

**4.3.3 Emergency Lightning**

4.3.3.1 An emergency lighting system is to be installed, the extent of which is to conform to 4.3.3.2.

4.3.3.2 For the following rooms and locations, adequate lighting and emergency lighting is to be provided:

a) locations where life-saving equipment is stored and where such equipment is normally prepared for use;

b) escape routes, access for passengers, including gangways, entrances and exits, connecting corridors, lifts and accommodation area companionways, cabin areas and accommodation areas;

c) markings on the escape routes and emergency exits;

d) in other areas intended for use by persons with reduced mobility;

e) operation rooms, engine rooms, steering equipment rooms and their exits;

f) wheelhouse;

g) emergency electrical power source room;

h) points at which extinguishers and fire extinguishing equipment controls are located;

i) areas in which passengers, shipboard personnel and crew muster in the event of danger

j) embarkation stations and over sides

4.3.3.3 The power supply and the duration of the supply is to conform to 4.2.

4.3.3.4 As far as practicable the emergency lighting system is to be installed in a manner, that it will not be rendered unserviceable by a fire or other incident in rooms in which the main source of electrical power, any associated transformers, the main switchboard and the main lighting distribution panel are installed.

4.3.3.5 The emergency lighting system is to be cut in automatically following a failure of the main power supply. Local switches are to be provided only where it may be necessary to switch off the emergency lighting (e.g. in the wheelhouse).

4.3.3.6 The light fittings for the emergency lighting is to be marked as such.

**4.4 Batteries, Accumulators and their charging devices**

4.4.1 Accumulators are not to be installed in the wheelhouse, accommodation area and holds, passenger spaces, cabins and galleys. The above requirement is not applicable for accumulators:

क) in mobile equipment; or

ख) with charging power of less than 0.2 [kW].

**4.5 Internal Communication Facilities**

**4.5.1 Communication from steering position**

4.5.1.1 All passenger vessels are to have internal communication facilities according to 4.5.1.2.

4.5.1.2 It is to be possible to establish communication links from the steering position:

a) with the bow of the vessel;

b) with the stern of the vessel if no direct communication is possible from the steering position;

c) with the crew accommodation;

d) with the master's cabin.

e) with service spaces

f) with engine room (control platform)

g) muster areas for passengers

Reception at all positions of these internal communication links is to be via loudspeaker, and transmission is to be via a fixed microphone. The link with the bow and stern of the vessel may be of the radio-telephone type.

**4.5.2 Public address systems**

4.5.2.1 Required public address systems are to comply with the relevant requirements of the appropriate Statutory Authority and with the following requirements.

4.5.2.2 The public address system is to be capable of broadcasting messages from the wheelhouse to:

a) all passenger spaces;

b) control stations where there is no other direct communication means from the wheelhouse; and

c) in the access and evacuation areas for passengers.

Loudspeakers may be omitted in passenger spaces where it can be demonstrated that effective direct communication between the wheelhouse and the passenger spaces is possible.

4.5.2.3 The system is to be designed in such a way as to ensure that the information transmitted can be clearly distinguished from background noise.

**4.6 Alarm System**

**4.6.1 Passenger and Crew Warning System**

4.6.1.1 The vessel is to be equipped with an alarm system enabling passengers, crew members and shipboard personnel to alert the vessel’s command and crew. This alarm is to be given only in areas assigned to the vessel’s command and to the crew; it should only be possible for the vessel’s command to stop the alarm. The alarm is to be capable of being triggered from at least the following places:

a) in each cabin;

b) in the corridors, lifts and stairwells, with the distance to the nearest trigger not exceeding 10 [m] and with at least one trigger per watertight compartment;

c) in accommodation area, dining rooms and similar recreation rooms;

d) in toilets, intended for use by persons with reduced mobility;

e) in engine rooms, galleys and similar rooms where there is a fire risk;

f) in the cold-storage rooms and other store rooms of high risk.

The alarm triggers are to be protected against unintentional use and installed at a height above the floor of 0.85 [m] to 1.10 [m];

**4.6.2 General Emergency Alarm System**

4.6.2.1 Required electrically operated bell or other equivalent warning systems for sounding the general emergency alarm signal are to comply with the relevant requirements of the appropriate Statutory Authority and with the requirements of this sub-Section.

4.6.2.2The vessel is to be equipped with an alarm system enabling the vessel's command to alert passengers. This alarm is to be clearly and unmistakably audible in all rooms accessible to passengers. It is to be capable of being triggered from the wheelhouse and from a location that is permanently staffed.

4.6.2.3 The vessel is to be equipped with an independent alarm system enabling the vessel's command to alert the crew and shipboard personnel, in the accommodation, engine rooms and where appropriate, pump rooms. The alarm system is also to reach the recreation rooms for the shipboard personnel, the cold-storage rooms and other store rooms of high risk. Alarm triggers are to be protected against unintentional use.

4.6.2.4 Means are to be provided to allow the system to be capable of sounding the alarm required by 4.6.2.3 independently of the alarm to the passenger spaces required by 4.6.2.2.

**4.7 Escape Guidance System**

4.7.1 Passenger vessels are to have suitable guidance systems to clearly identify the escape routes and emergency exits when the normal emergency lighting is less effective due to smoke. Such guidance systems are to take the form of low-location lighting (LLL).

4.7.2 In addition to the emergency lighting as required by 4.3.3 the escape routes, including stairways, exits and emergency exits, are to be marked by low-location lighting (LLL) throughout the whole of the escape route, particularly at corners and intersections.

**4.8 Watertight Doors and Doors**

4.8.1 Refer to Section 2 for the requirements for watertight doors and doors.

## Section 5

## Fire Protection, Detection and Extinction

### 5.1 General

### 5.1.1 Statutory Requirements

5.1.1.1 Attention is drawn to fire safety requirements of National/Local Authorities where the vessel is registered or operating.

### 5.1.2 Documentation

5.1.2.1 For fire safety of passenger vessels additional plans and information are to be submitted as detailed below for approval:

a) Structural fire protection, showing the method of construction, purpose and category of the various spaces of the vessels, the fire rating of bulkheads and decks, means of closings of openings divisions, draught stops.

b) Ventilation systems showing the penetrations on divisions, location of dampers, means of closing, etc.

c) Escape plan

### 5.2 Definitions

5.2.1 **Non-combustible**: a substance which neither burns nor produces flammable vapours in such quantities that they ignite spontaneously when heated to approximately 750 [°C];

5.2.2 **Flame-retardant**: material which does not readily catch fire, or whose surface at least restricts the spread of flames pursuant to the following test procedures :

a) Code for Fire Test Procedures, Annex 1 Part 5 (Test for surface flammability - Test for surface materials and primary deck coverings),

b) Code for Fire Test Procedures, Annex 1 Part 7 (Test for vertically supported textiles and films)

c) Code for Fire Test Procedures, Annex 1 Part 8 (Test for upholstered furniture)

d) Code for Fire Test Procedures, Annex 1 Part 9 (Test for bedding components) of the;

5.2.3 **Self-extinguishing**: the characteristic of a burning substance whereby it extinguishes itself of its own accord within a short period once the ignition source has been removed, i.e. does not continue to burn;

5.2.4 **Fire-resistance**: the property of structural components or devices as certified by the following test procedure :

a) Code for Fire Test Procedures Annex 1, Part 3, (Part 3 – Test for "A", "B" and "F" class divisions)

5.2.5 **Code for Fire Test Procedures**: the International Code for the Application of Fire Test Procedures (FTP code) adopted under Resolution MSC.307(88) by the Maritime Safety Committee of the International Maritime Organization (IMO);

### 5.3 Fire Prevention

### 5.3.1 Testing

5.3.1.1 The suitability for fire protection of materials and components is to be established by an accredited test institution based on appropriate test methods.

### 5.3.2 Structural Fire Protection

5.3.2.1 The minimum required fire integrity of all bulkheads and decks is shown in Table 5.3.2.1 (a) or 5.3.2.1(b), as applicable. Requirements given in Table 5.3.2.1 (a) and 5.3.2.1 (b) are not applicable to day trip vessels of length less than 24 [m].

5.3.2.2 In day trip vessels of length less than 24 [m], the machinery space boundaries are to be constructed of steel (rated A0) or equivalent material. The engine space is to be capable of being closed down in order that the fire extinguishing medium cannot escape. Where it is not practical to have a machinery space, the engine is to be enclosed in a box. The box is to perform the same function as the machinery space boundaries referred earlier. Partitions between galley, store rooms of high risk containing flammable liquids and other areas are also to be of Type A0 or equivalent material.

**Table 5.3.2.1(a) : Partitions between rooms, in which no pressurised sprinkler systems according to Annex 3, Ch.9, 4.2 are installed**

| Rooms | Control centres | Stairwells | Muster areas | Accommodation Spaces | Engine Rooms | Galleys | Store Rooms of high risk |
|---|---|---|---|---|---|---|---|
| Control Centres | - | A0 | A0/B15[1)] | A30 | A60 | A60 | A0/A60[5)] |
| Stairwells | | - | A0 | A0 | A60 | A0 | A0/A30[5)] |
| Muster Areas | | | - | A0/B15[2)] | A60 | A30 | A0/A60[5)] |
| Accommodation Spaces | | | | -/A0/B0[3)] | A60 | A30 | A0/A30[5)] |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Engine Rooms | | | | | A60/A0[4)] | A60 | A60 |
| Galleys | | | | | | A0 | A30/A0/B15[6)] |
| Store Rooms of high risk | | | | | | | - |

**Table 5.3.2.1(b): Partitions between rooms, in which pressurised sprinkler systems according to Annex 3, Ch.9, 4.2 are installed**

| Rooms | Control centres | Stairwells | Muster areas | Accommodation spaces | Engine Rooms | Galleys | Store Rooms of high risk |
|---|---|---|---|---|---|---|---|
| Control Centres | - | A0 | A0/B15[1)] | A0 | A60 | A30 | A0/A30[5)] |
| Stairwells | | - | A0 | A0 | A60 | A0 | A0 |
| Muster Areas | | | - | A0/B15[2)] | A60 | A0 | A0/A30[5)] |
| Accommodation Spaces | | | | -/B15/B0[3)] | A60 | A0 | A0 |
| Engine Rooms | | | | | A60/A0[4)] | A60 | A60 |
| Galleys | | | | | | - | A0/B15[6)] |
| Store Rooms of high risk | | | | | | | - |

1) Partitions between control centres and internal muster areas are to correspond to Type A0, but external muster areas only to Type B15.

2) Partitions between accommodation spaces and internal muster areas are to correspond to Type A0, but external muster areas only to Type B15.

3) Partitions between cabins and corridors are to comply with Type B0. Partitions between cabins and saunas are to comply with Type A0, for rooms that are fitted with pressurised sprinkler systems, they are to comply with type B15.

4) Partitions between engine rooms according to 4.2.4.1 are to comply with Type A60; in other cases they are to comply with Type A0.

5) Partitions between store rooms for the storage of flammable liquids and control centres / muster areas are to comply with Type A60, for rooms fitted with pressurised sprinkler systems A30. Partitions between store rooms for the storage of flammable liquids and stairwells/ accommodation spaces are to be of Type A30.

6) Partitions between store rooms for the storage of flammable liquids and galleys are to be of Type A30 and A0 where pressurized sprinklers are fitted. Partitions between other store rooms of high risk and galleys are to be of Type A0. Type B15 is sufficient for partitions between galleys, on one side, and cold-storage rooms and food store rooms of high risk, on the other.
7) Windows below the muster areas/embarkation stations are to have same fire integrity as the structure on which it is fitted.

5.3.2.3 For the purpose of determining the appropriate fire integrity standard to be applied to boundaries between adjacent spaces, such spaces are classified according to their fire risk described in the following categories. The title of each category is intended to be typical rather than restrictive.

a) Control Centres : a wheelhouse, an area which contains an emergency electrical power plant or parts thereof or an area with a centre permanently occupied by crew , such as for fire alarm equipment, remote controls of doors or fire dampers;

b) Stairwell: the well of an internal staircase or of a lift;

c) Muster Areas: areas of the vessel which are specially protected and in which persons muster in the event of danger;

d) Accommodation Spaces: a room of an accommodation or a passenger space. On-

board passenger vessels, galleys are not regarded as accommodation space.

e) Engine Room: space where combustion engines are installed;

f) Galley: a room equipped with an open flame cooking appliance or any electrically heated cooking plate or hot plate with a power of not more than 5 [kW];

g) Store Room of high risk: a room for the storage of flammable liquids or a room with an area of over 4 [$m^2$] for storing supplies.

5.3.2.4 Type A partitions are bulkheads, walls and decks which satisfy the following requirements:

a) They are made of steel or of another equivalent material;

b) They are appropriately stiffened;

c) They are insulated with an approved non-combustible material such that the average temperature on the side facing away from the fire rises to not more than 140 [°C] above the initial temperature and at no point, including the gaps at the joints, does a temperature increase of more than 180 [°C] above the initial temperature occur within the following specified periods:

Type A60 :60 minutes

Type A30 :30 minutes

Type A0 :0 minutes;

d) they are constructed in such a way as to prevent the transmission of smoke and flames until the end of the one-hour standard fire test;

5.3.2.5 Type B partitions are bulkheads, walls, decks, ceilings or facings that meet the following requirements:

a) they are made of an approved non-combustible material. Furthermore, all materials used in the manufacture and assembly of partitions are to be non-combustible, except for the facing, which is to be at least flame retardant;

b) they demonstrate an insulation value such that the average temperature on the side facing away from the fire rises to not more than 140 [°C] above the initial temperature and at no point, including the gaps at the joints, does a temperature increase of more than 225 [°C] above the initial temperature occur within the following specified periods:

Type B15 : 15 minutes

Type B0 : 0 minutes;

c) they are constructed in such a way as to prevent the transmission of flames until the end of the first half hour of the standard fire test.

5.3.2.6 Paints, lacquers and other surface treatment products as well as deck coverings used in rooms except engine rooms and store rooms of high risk are to be flame-retardant. Carpets, fabrics, curtains and other hanging textile materials as well as upholstered furniture and components of bedding are to be flame-retardant, if the rooms in which they are located are not equipped with a pressurised sprinkler system according to Annex 3, Ch.9, 4.2.

5.3.2.7 Ceilings and wall claddings of accommodation spaces, including their substructures, where these accommodation space do not have a pressurised sprinkler system in accordance with Annex 3, Ch.9, 4.2, are to be manufactured from non-combustible materials with the exception of their surfaces, which are to be at least flame-retardant. This requirement does not apply to saunas.

5.3.2.8 Furniture and fittings in accommodation space which serve as muster areas, where a pressurised sprinkler system according to Annex 3, Ch.9, 4.2 is not fitted, are to be manufactured from non-combustible materials.

5.3.2.9 Paints, lacquers and other materials used on exposed internal surfaces are not to produce excessive amounts of smoke or toxic substances. This is to be proven in accordance with the Code for Fire Test Procedures.

5.3.2.10 Insulation materials in accommodation spaces are to be non-combustible. This does not apply to insulations used on coolant-carrying pipes. The surfaces of the insulation materials used on these pipes are to be at least flame-retardant.

5.3.2.11 Awnings and similar mobile installations with which deck areas are fully or partially enclosed and their substructures are to be at least flame-retardant.

5.3.2.12 Doors in partitions according to 5.3.2.1 are to satisfy the following requirements:

a) They are to satisfy the same requirements set out in 5.3.2.1 as the partitions themselves.

b) They are to be self-closing in the case of doors in partition walls according to 5.3.2.13 or in the case of enclosures around engine rooms, galleys and stairwells.

c) Self-closing doors which remain open in normal operation are to be such that they can be closed from a location permanently occupied by crew; Once a door has been remotely closed, it is to be possible to reopen and close it safely on the spot.

d) Watertight doors according to Sec 2 need not be insulated.

5.3.2.13 Walls according to 5.3.2.1 are to be continuous from deck to deck or end at continuous ceilings, which satisfy the same requirements as referred to in 5.3.2.1.

5.3.2.14 The following passenger spaces are to be divided by vertical partitions of at least A-0 fire integrity and continuous from deck to deck (also refer to 5.3.2.1):

a) passenger spaces with a total surface area of more than 800 [$m^2$];

b) passenger spaces in which there are cabins, at intervals of not more than 40 [m].

5.3.2.15 Hollows above ceilings, beneath floors and behind wall claddings are to be separated at intervals of not more than 14 [m] by non-combustible draught stops which, even in the event of fire, provide an effective fireproof seal.

5.3.2.16 Stairs are to be made of steel or another equivalent non-combustible material.

5.3.2.17 Internal stairs and lifts are to be encapsulated at all levels by walls according to 5.3.2.1. The following exceptions are permissible:

a) a staircase connecting only two decks does not need to be encapsulated, if on one of the decks the staircase is enclosed according to 5.3.2.1;

b) in an accommodation space, stairs need not be encapsulated if they are located entirely within the interior of this room, and

i) if this room extends over only two decks, or

ii) if there is a pressurised sprinkler system according to Annex 3, Ch.9, 4.2 installed in this room on all decks, this room has a smoke extraction system according to 5.3.4 and the room has access on all decks to a stairwell.

**5.3.3 Ventilation System**

5.3.3.1 Ventilation systems and air supply systems are to satisfy the following requirements:

a) they are to be designed in such a way as to ensure that they themselves do not cause the spread of fire and smoke;

b) openings for air intake and extraction and air supply systems are to be such that they can be closed off;

c) ventilation ducts are to be made from steel or an equivalent non-combustible material and be securely connected to each other and to the superstructure of the vessel;

d) when ventilation ducts are passed through partitions according to 5.3.2.1 of Type A, or partitions according to 5.3.2.14, they are meet the following requirements:

i) with a cross sectional area equal to, or less than, 0.02 [$m^2$], are to be fitted with a steel sheet sleeve having a thickness of at least 3 [mm] and a length of at least 200 [mm], divided preferably into 100 [mm] on each side of a bulkhead or, in the case of a deck, wholly laid on the lower side of the decks penetrated;

ii) with a cross sectional area exceeding 0.02 [$m^2$], but not more than 0.075 [$m^2$], the openings are to be lined with steel sheet sleeves. The sleeves are to have a thickness of at least 3 [mm] and length of at least 900[mm] when passing through bulkheads, this length is to be divided preferably into 450 [mm] on each side of the bulkhead. These ducts, or sleeves lining such ducts, are to be provided with fire insulation. The insulation is to have at least the same fire integrity as the division through which the duct passes.

iii) with a cross-sectional area exceeding 0.075 [$m^2$] to be fitted with automatic fire dampers which can be operated from a location permanently manned by crew.

e) ventilation systems for galleys and engine rooms are to be separated from ventilation systems which supply other areas;

f) air extraction ducts are to be provided with lockable openings for inspection and cleaning. These openings are to be located close to the fire dampers;

g) built-in ventilators are to be such that they can be switched off from a central location outside the engine room.

5.3.3.2 Galleys are to be fitted with ventilation systems and stoves with extractors. The air extraction ducts of the extractors are to satisfy the requirements according to 5.3.3.1 and, additionally, be fitted with manually operated fire dampers at the inlet openings. Insulation on galley ducts are to be in accordance with the applicable requirements of 5.3.2.1 for galley.

**5.3.4 Control of Smoke Spread**

5.3.4.1 In vessels of 24 m length and over, control centres, stairwells and internal muster areas are to be fitted with natural or mechanical smoke extraction systems. Smoke extraction systems are to satisfy the following requirements:

a) they are to offer sufficient capacity and reliability;

b) they are to comply with the operating conditions for passenger vessels;

c) if smoke extraction systems also serve as general ventilators for the rooms, this shall not hinder their function as smoke extraction systems in the event of a fire;

d) smoke extraction systems are to have a manually operated triggering device;

e) mechanical smoke extraction systems are to additionally be such that they can be operated from a location permanently occupied by crew;

f) natural smoke extraction systems are to be fitted with an opening mechanism, operated either manually or by a power source inside the extraction system;

g) manually operated triggering devices and opening mechanisms are to be accessible from inside or outside the room being protected.

**5.4 Fire Detection**

**5.4.1 General**

5.4.1.1 Accommodation spaces, galleys, engine rooms and other rooms presenting a fire risk are to be connected to a fire alarm system (See Annex 3 Ch.9, Sec.3). The existence of a fire and its exact whereabouts is to be automatically displayed at a location permanently manned by crew members. Provision of fire alarm systems for accommodation spaces constantly supervised by crew may be specially considered.

5.4.1.2 On passenger vessels, which do not have a fire detection system with remote identification of individual fire detectors, a fire detection section is not to comprise more than the area constituted in accordance with 5.3.2.14. The activation of a fire detector in an individual cabin in this fire detection section is to set off a visual and acoustic signal in the passageway outside that cabin.

5.4.1.3 Power supply requirements for fire alarm system are to be as per Annex 3, Ch. 9, 3.2.2.2. With respect to requirements of Annex 3, Ch. 9, 3.2.2.2.2, on day-trip vessels up to 25 [m] length, a separate emergency power supply is sufficient.

## Section 6

## Additional Requirements for Ro-Ro PAX

**6.1 General**

**6.1.1 Application**

6.1.1.1 This section applies to Ro Ro PAX vessels.

**6.1.2 Definition**

6.1.2.1 Special category spaces are those enclosed vehicle spaces above and below the bulkhead deck, into and from which vehicles can be driven and to which passengers have access. Special category spaces may be accommodated on more than one deck.

**6.1.3 Documentation to be submitted**

6.1.3.1 In addition to the documentation required other parts of the rules following information is to be submitted:

a) Plans of ramps, elevators for vehicle/ cargo handling including structural and operational arrangements and test conditions.

b) Plan of arrangement of motor vehicles, railway cars and/or other types of vehicles which are intended to be carried and indicating securing and load bearing arrangements

c) Characteristics of motor vehicles, railways cars and/or other types of vehicles which are intended to be carried: (as applicable) axle load, axle spacing, number of wheels per axle, wheel spacing, size of tyre print.

d) Plan of dangerous areas, of vessels intended for the carriage of motor vehicles with fuel in their tanks.

**6.2 Vessel arrangements**

**6.2.1 Ro-Ro Deck**

6.2.1.1 Where vehicle ramps are installed to give access to spaces below the bulkhead deck, their openings are to be able to be closed weathertight to prevent ingress of water below. Such opening are to be alarmed with audible and visual indication to the navigation bridge

**6.3 Hull structure**

**6.3.1 Framing**

6.3.1.1 In general, car decks or platforms are to be longitudinally framed. Where a transverse framing system is adopted, it is to be considered by Designated Authority on a case-by-case basis.

**6.4 Drainage of Ro-Ro spaces, intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion**

**6.4.1 Scupper draining**

6.4.1.1 Scuppers from cargo spaces intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion are not to be led to machinery or other places where sources of ignition may be present.

**6.5 Electrical installations**

**6.5.1 Protective measures on car decks**

**6.5.1.1 Installations in special category spaces situated above the bulkhead deck**

6.5.1.1.1 On any deck or platform, if fitted, on which vehicles are carried and on which explosive vapours might be expected to accumulate, except for platforms with openings of sufficient size permitting penetration of fuel gases downwards, electrical equipment and cables are to be installed at least 450 [mm] above the deck or platform. Where the installation of electrical equipment and cables at less than 450 [mm] above the deck or platform is deemed necessary for the safe operation of the vessel, the electrical equipment is to be of a certified safe type as stated in 6.5.1.1.2 and to have the minimum explosion group IIA and temperature class T3. Electrical equipment is to be as stated in 6.5.1.1.3

6.5.1.1.2 Electrical equipment are not to be installed or operated in areas subject to explosion hazard, with the exception of explosion-protected equipment of a type suitable for shipboard use. Electrical equipment is deemed to be explosion protected, if they are manufactured to a recognized standard such as IEC 60079 publications or EN 50014-50020, and if they have been tested and approved by a testing authority recognized by Designated Authority. Notes and restrictions at the certificate have to be observed. Cables are to be armoured or screened, or run inside a metal tube.

6.5.1.1.3 For equipment in these areas protective measures are to be taken which, depending on the type and purpose of the equipment, could comprise e.g.:

- use of explosion-protected facilities, or
- use of facilities with type Ex n protection, or
- use of facilities which in operation do not cause any sparks and whose surfaces, which are accessible to the open air, do not attain any unacceptable temperatures, or
- facilities which in a simplified way are overpressure encapsulated or are fumetight-encapsulated (minimum protection type IP 55) and whose surfaces do not attain any unacceptable temperatures.

**6.5.1.2 Installations in special category spaces situated below the bulkhead deck**

6.5.1.2.1 An electrical equipment installed is to be as stated in 6.5.1.1.2 and to have the minimum explosion group IIA and temperature class T3.

**6.5.1.3 Ventilation**

6.5.1.3.1 Electrical equipment and cables in exhaust ventilation ducts are to be as stated in 6.5.1.1.2 and to have the minimum explosion group IIA and temperature class T3.

**6.6 Fire Safety**

**6.6.1 Fire Protection**

6.6.1.1 The boundary bulkheads and decks surrounding ro-ro deck spaces are to be insulated to A60 standard. However, where an open deck space (that is not a passenger space, muster station or evacuation station), a sanitary or similar space, void or auxiliary machinery space having little or no fire risk, is on one side of the division, this standard may be reduced to A0.

6.6.1.2 Adequate ventilation is to be provided in special category spaces, sufficient to give at least 10 air changes per hour.

**6.6.2 Fire Fighting**

6.6.2.1 Enclosed ro-ro deck spaces are to be fitted with an approved fixed pressure water-spraying system for manual operation, which is to protect all parts of any deck and vehicle platform in such spaces.

6.6.2.2 In view of serious loss of stability, which could arise due to large quantities of water accumulating on the deck or decks consequent on the operation of fixed pressure water-spraying system, scuppers are to be fitted so as to ensure that such water is rapidly discharged directly overboard.

# Chapter 4

# Tugs

**Contents**



## Section 1

## General

### 1.1 Application

1.1.1 The requirements of this chapter apply to tugs and are supplementary to those given in Annex 2.

A tug is a vessel designed primarily for towage of other vessels, which does not exclude occasional pushing duties, if arranged for this purpose.

A pusher tug is a vessel designed primarily for pushing other vessels.

### 1.2 Documentation

1.2.1 The following additional plans and documents are to be submitted for approval, as applicable.

Towing arrangement

- Maximum and continuous bollard pull and the breaking strength of the tow rope.

Towing hook

- It's attachment and corresponding strengthening of hull structure, slip arrangements.

Bollard Pull test program

- Items specified in Sec.6.

1.2.2 Additional Certificates of Approval are to be submitted for :-

a) Towing hook with attachments

b) Towline.

### 1.3 Materials

1.3.1 Towing hook including its attachment is to be made of forged steel, special quality carbon and carbon-manganese steel castings or fabricated from rolled steel products manufactured and tested in accordance with Annex 1.

## Section 2

## Hull Arrangement and Strength

### 2.1 General

2.1.1 The draught T, used for determination of scantlings is not to be taken less than 0.90 D.

2.1.2 The structure in the forebody and afterbody is to be adequately reinforced against forces arising from pushing operations.

2.1.3 Structure in way of openings provided for fitment of propulsion units is to be reinforced to ensure the continuity of longitudinal and transverse strength.

2.1.4 Single bottom floors clear of the machinery space may be flanged in lieu of a face plate.

### 2.2 Side structure

2.2.1 In fore peak space, side stringers supporting vertical peak frames are to be fitted at mid-height.

2.2.2 For tugs engaged in berthing operations, it is recommended to provide a stringer all around the vessel at a suitable height, to provide additional stiffness against contact.

### 2.3 Deck structure

2.3.1 Foundations of towing winch and towing hook are to be capable of withstanding the breaking strength of the towline without any permanent deformations. The design of structures under these foundations and under heavy duty bollards is to be based on additional loads imposed by the tow line at its breaking strength.

**2.4 Machinery casings, emergency exits, scuttles, air pipes, ventilators & bulwark etc.**

2.4.1 Exposed machinery casings are generally to be not less than 900 [mm] high above the upper surface of the deck. Proposals of reduced height to facilitate lowering of the towline, will receive individual consideration on the basis of safety against the ingress of water.

The scantlings of the exposed machinery casings are to be 20% more than those required for exposed deckhouses in the same location and at the casing stiffeners are to be connected to beams at both ends.

2.4.2 Emergency exit from the machinery space to the deck is to be capable of being used at extreme angles of heel and is to be located on or near the vessel's centreline. The coaming height is to be not less than 450 [mm]. The hatch cover is to have hinges arranged athwartships and is to be capable of being opened and closed weathertight from either side.

2.4.3 Side scuttles are generally not permitted below the main deck except under special consideration when the distance from the lower edge of side scuttles to the waterline is at least 750 [mm] and the scuttles of non-opening type with hinged inside deadlights meeting the requirements of Type A (heavy) scuttles according to ISO Recommendation 1751, are provided.

Fixed lights of skylights on the deck are to have glass thickness appropriate to their location as required for side scuttles, and fitted with hinged deadlight on the weather side.

2.4.4 In the area aft of the tow hook, the air pipes and vent pipes are to be so arranged as to prevent damage from the towline and to provide maximum practicable angle of downflooding. Closing appliances on air pipes on upper deck the upper end of which may get immersed at an angle of 30° are to be of automatic type.

2.4.5 The bulwarks are to be sloped inboard to avoid damage due to contact.

**2.5 Sternframe, rudder & steering gear**

2.5.1 In the case of tugs designed for maximum helm angle more than 35°, the scantlings of the rudder, rudder stock, stern frame and the steering gear will be specially considered.

**2.6 Fenders**

2.6.1 In addition to the special fendering provided for pushing operations, an efficient fender is to be fitted all around on the vessels's side at deck level.

## Section 3

## Towing Arrangement

**3.1 General**

3.1.1 The towline is to be in accordance with Annex 2, Ch.13, Sec.3.2.

3.1.2 The position of the towing hook or towing winch is to be carefully selected so as to minimise the heeling moment as well as the risk of girting due to the pull exerted by the tow rope.

**3.2 Towing hook**

3.2.1 Towing hook should be provided with an efficient slip arrangement to facilitate release of the towline regardless of the angle of heel and the direction of the towline. The releasing device is also to be operable from the bridge. The breaking strength of the hook, or its equivalent should at least be 50 percent more than that of the towline.

## Section 4

## Pushing Arrangements

**4.1 General**

4.1.1 Pusher tugs relying on direct contact for pushing are to be fitted with push stems or push knees and adequate coupling arrangements, such as winches and wires, are to be provided. Unless the stem is designed to fit into a slot in the pushed vessel, a twin push stem/knee is recommended. The push stem or pushing knees are to be adequately supported and integrated into the fore peak structure.

4.1.2 Where the transmission of forces from the pusher tug to be pushed vessel is arranged through rigid or semi-rigid coupling arrangements, the connecting devices as well as their supporting hull structure are to be in accordance with Ch.5, Sec.3.

## Section 5

## Stability

**5.1 General**

5.1.1 In addition to the general requirements, the stability of tugs is to be assessed considering the effect of transverse heeling force caused when the tow rope is not in line with the tug's longitudinal centerline. Compliance with the following criteria is recommended, as a minimum :

$GZ' > 1.5\ (F_t \cdot l_v)\ /\ (\text{Displacement})$ [m]

GZ’ = Righting lever GZ, [m], at angle of deck immersion or at 30 degrees, whichever is lower.

$F_t$ = The transverse heeling force, [tonnes], generally may be taken at 0.5 BPmax.

$I_v$ = Vertical distance, [m], from the center of propeller(s) to the center of towline.

## Section 6

## Tests and Trials

### 6.1 Towing gear

6.1.1 In addition to the tests at the manufacturer's works, the towing gear including the towing hook, winch and their emergency release systems are to be tested after installation.

### 6.2 Bollard pull test procedure

6.2.1 The proposed test programme is to be submitted prior to the testing.

6.2.2 Test for continuous bollard pull is to be carried out with the main engines running at the maximum attainable engine RPM without exceeding the maximum RPM and torque recommended by the engine builder for continuous operation.

6.2.3 The test is to be carried out with the vessel's own propellers only. All auxiliary machinery which are normally driven from the main engine(s) or propeller shaft(s) while towing, are to be connected during the test.

6.2.4 The test is to be conducted in fair weather and at location where sufficient water depth and distance between the tug and the shore bollard is available. Corrections to the measured values of the bollard pull on any account will not be admissible.

6.2.5 An approved and calibrated load measuring device, preferably giving a continuous read-out is to be fitted between the eye of the towline and the bollard.

6.2.6 During the test, efficient communication is to be maintained between the vessel and the shore personnel recording the bollard pull.

6.2.7 The vessel is to maintain a fixed course for at least 10 minutes during which the bollard pull is to be recorded.

6.2.8 The pull maintained uniformly for minimum of 10 minutes without any tendency to decline shall be certified as the vessel's continuous bollard pull, subject to a limit of 50% of the breaking strength of the towline supplied.

# Chapter 5

# Barges and Pontoons

**Contents**



## Section 1

## General

### 1.1 Application

1.1.1 The requirements of this chapter apply to manned or unmanned barges and pontoons and are supplementary to those given for the assignment of main characters of class.

Barges are non-self propelled vessels designed and constructed for carriage of dry cargoes in holds or liquid cargoes in tanks.

Pontoons are non-self propelled vessels designed and constructed for carriage of non-perishable cargoes or equipment on deck.

### 1.2 Documentation

1.2.1 The following additional plans and documents are to be submitted for approval, as applicable.

- Towing arrangement and details of towing brackets, bollards and other fittings with under deck stiffening.

- Details of structure and fittings, if any, to which deck cargo securing lashings etc. are attached.
- In case of pusher tugs or integral tug/barge systems or combination units comprising many modules, details of the connecting elements, attachments and supporting structures.

**Section 2**

**Hull Arrangement and Strength**

**2.1 General**

2.1.1 Where a rudder is not fitted, the Rule length, L, is to be taken as 97% of the length of the load waterline at draught T.

In case of pusher tug/barge units with rigid connections, the Rule length, L, is to be based on the combined length of the tug and barge.

**2.2 Bottom structure**

2.2.1 For barges and pontoons having no rise of floor, the keel plate thickness may be same as adjacent bottom shell.

2.2.2 On hard chine vessels, where a solid round bar is provided at the knuckles, the diameter of round chine bar is not to be less than three times the bottom plate thickness.

**2.3 Truss arrangements**

2.3.1 A truss is a system of internal framing members comprising deck and bottom girders in association with regularly spaced stanchions and diagonal bracings inclined at about 45 degrees with the horizontal, in each space between the stanchions.

2.3.2 The scantlings of platings, stiffeners and girders are not to be less than the general requirements given in Annex 2, except as specified in 2.3.3. below.

2.3.3 The section modulus of bottom girders is not to be less than that required by Annex 2, Ch.6, Sec.5, taking the value of the coefficient 'm' as 6.

The section modulus of deck girders is not to be less than that required by Annex 2, Ch.8, Sec.5, taking the value of the coefficient 'm' as 8.

2.3.4 The scantlings of stanchions are to be based on the external pressure on bottom or the static cargo load on deck, whichever is higher; and the buckling requirements given in Annex 2, Ch.3, Sec.6. Stanchions in tank spaces are also to be checked for tension caused by internal pressure.

2.3.5 The cross sectional area of diagonals may be approximately 50% of that of the adjacent stanchion.

**Section 3**

**Pushing, Towing - Devices and Connecting Elements**

**3.1 General**

3.1.1 Devices for pushing and towing of linked barges as well as the elements connecting the modular units are to be adequately dimensioned for the acting external forces calculated considering all possible load combinations. Towing gear, brackets and bollards are to be adequately dimensioned for the estimated towing pull considering the displacement and towing speed.

3.1.2 The scantlings of these devices and elements as well as their supporting structures are to be based on following permissible stresses :

bending and normal stress $\sigma = 100/k$ [$N/mm^2$]

shear stress $\tau = 60/k$ [$N/mm^2$]

equivalent stress,

$\sqrt{\sigma^2 + 3\tau^2} = 120/k$ [$N/mm^2$].

**Section 4**

**Machinery and Electrical Installation**

**4.1 General**

4.1.1 Machinery and electrical installations, when provided are to comply with the requirements of Annex 3

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ಕರ್ನಾಟಕ ರಾಜ್ಯಪಾಲರ ಆದೇಶಾನುಸಾರ
ಮತ್ತು ಅವರ ಹೆಸರಿನಲ್ಲಿ
(ಡಿ.ಬಿ. ಜನಾರ್ಧನ)
ಸಹಾಯಕ ಪ್ರಾರೂಪಕಾರ ಮತ್ತು ಪದನಿಮಿತ್ತ
ಸರ್ಕಾರದ ಉಪ ಕಾರ್ಯದರ್ಶಿ
ಸಂಸದೀಯ ವ್ಯವಹಾರಗಳು ಮತ್ತು
ಶಾಸನ ರಚನೆ ಇಲಾಖೆ

**PR-76**

ಮುದ್ರಕರು ಹಾಗೂ ಪ್ರಕಾಶಕರು:– ಸಂಕಲನಾಧಿಕಾರಿಗಳು, ಕರ್ನಾಟಕ ರಾಜ್ಯಪತ್ರ, ಸರ್ಕಾರಿ ಕೇಂದ್ರ ಮುದ್ರಣಾಲಯ, ಬೆಂಗಳೂರು–೫೯.